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An Evaluation from Multiuse Management Standpoint

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16. ABSTRACT

This report evaluated from a multiuse management standpoint the operation of the Old River Control Project. It was found that limiting diversions to the extent presently being considered by the Old River Control Project would effectively remove those wetlands that are presently flooded for a period of 0 to 4 months from the aquatic ecosystem as a type habitat representing as much as 36 percent of the wetlands of the overflow areas in the Atchafalaya Basin. Without stronger land-use controls, a reduction in the annual extent of flooding could encourage new residential and agricultural development in the present wetlands. This in turn will increase agricultural runoff into adjacent wetlands that are already affected by such runoff and in which water circulation is impeded by a backwater regime as a result of past flood control increases. In order to minimize the present loss of wetlands in the Atchafalaya Basin as a result of river profile adjustments, the present diversion of water must be at least maintained. However, the complete maintenance of present wetlands requires an increase of diverted discharges to offset the trend toward reduction in the extent, duration, and depth of flooding.

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* After June 4, 1979, the Environmental Monitoring Systems Laboratory.

FOREWORD

Protection of the environment requires effective regulatory actions that are based on sound technical and scientific information. This information must include the quantitative description and linking of pollutant sources, transport mechanisms, interactions, and resulting effects on man and his environment. Because of the complexities involved, assessment of specific pollutants in the environment requires a total systems approach that transcends the media of air, water, and land. The Environmental Monitoring and Support Laboratory-Las Vegas contributes to the formation and enhancement of a sound, integrated monitoring data base for exposure assessment through programs designed to:

- develop and optimize systems and strategies for monitoring pollutants and their impact on the environment
- demonstrate new monitoring systems and technologies by applying them to fulfill special monitoring needs of the Agency's operating programs

This report evaluates the operation of the Old River Control Project in the Atchafalaya Basin from a multiuse management standpoint. The U.S. Environmental Protection Agency, the U.S. Army Corps of Engineers, the U.S. Department of the Interior, the State of Louisiana, special interest groups, and other interested individuals will use this information to assess the potential impact of proposed hydrological modifications and to develop alternative land and management plans, which will accommodate floodflows and maintain an acceptable level of environmental quality. For further information contact the Water and Land Quality Branch, Monitoring Operations Division.

George B. Morgan
Director
Environmental Monitoring and Support Laboratory
Las Vegas

SUMMARY

The Atchafalaya Basin in south-central Louisiana is a large alluvial basin whose wetlands are of national significance. To meet the need for flood control, the U.S. Army Corps of Engineers is considering hydrological modifications for the Basin. The Basin's present hydrological cycle and complex water circulation patterns support one of the world's most highly natural productive areas.

In response to a request by the Governor of Louisiana and a joint U.S. Congressional resolution, the U.S. Environmental Protection Agency (EPA), U.S. Army Corps of Engineers (USCE) and the U.S. Department of Interior are conducting a water and land quality study in the Atchafalaya River Basin. This study is assessing the potential impact of proposed hydrological modifications and developing alternative land and water management plans to accommodate flood-flows and maintain an acceptable level of environmental quality for the Atchafalaya Basin.

Objectives of the EPA in the Atchafalaya Basin include: 1) land use requirements to control agriculturally related nonpoint sources of pollution (Federal Water Pollution Control Act Amendment (FWPCAA), 1972, Sec. 208); 2) the 1983 goal of water quality, which provides for the protection and propagation of fish, shellfish, and wildlife and provides for recreation in and on the water, and the restoration and maintenance of the chemical, physical, and biological integrity of the Nation's water (FWPCAA, 1972, Sec. 101); 3) avoidance of degradation in any way of waters that in their existing condition could be used for sport fishing with degradation reducing their value for that use; 4) reduction of the adverse impact of spoil disposal on fishery, wildlife, or recreational areas (FWPCAA, 1972, Sec. 404); 5) monitoring of the discharge of dredged material in wetlands; 6) the avoidance of long- and short-term adverse impacts associated with destruction and modification of wetlands (Exec. Order 11990); 8) the avoidance of direct or indirect support of new construction in wetlands (Exec. Order 11990); 9) the avoidance, to the extent possible, of long- and short-term adverse impacts associated with the occupancy and modification of flood plains (Exec. Order 11988); 10) the avoidance of direct or indirect support of flood-plain development whenever there is a practicable alternative (Exec. Order 11988); and 11) the avoidance of discharge of material that would have an unacceptable adverse effect on municipal water supplies, shellfish beds, and fishery, wildlife, or recreational areas (Public Law 92-500, Sec. 404, C).

The Atchafalaya Basin extends inland from the Gulf of Mexico for a distance of 125 miles to the confluence of Red River and distributary flows from the Mississippi River. The Old River Project was placed into operation in 1963 to regulate, by control structures, the diversion of Mississippi River flow into the Atchafalaya River. Previous to this it was noted that unregulated flows from the Mississippi River were steadily increasing and that in the absence of man's intervention the Mississippi River would change its course to that of the Atchafalaya River. The Old River Project is now being operated so that the proportions of flow between the Mississippi and Atchafalaya Rivers are the same as occurred in 1950, i.e., 30 percent of the latitude flow is carried by the Atchafalaya River and 70 percent by the Mississippi River. The volume of water that is allowed through the control structure determines the character of the aquatic ecosystems in the Atchafalaya Basin and the Red River backwater area.

Various alternatives for the future operation of the Old River Control Project are being considered. These are: 1) maintain present diversion from the Mississippi River; 2) limit diversion so that storages in the Red River backwater area are reduced during the spring planting season and the area currently inundated is reduced; and 3) manage diversion in order to meet the requirements of the aquatic ecosystems in the Atchafalaya Basin. This report evaluates the operation of the Old River Control Project from a multiuse management standpoint.

It was found that limiting diversions to the extent presently being considered by the Old River Control Project would effectively remove those wetlands that are presently flooded for a period of 0 to 4 months from the aquatic ecosystem. This type habitat represents as much as 36 percent of the wetlands of the overflow areas in the Atchafalaya Basin. Without stronger land use controls, a reduction in the annual extent of flooding could encourage new residential and agricultural development in the present wetlands. This in turn would increase agricultural runoff into adjacent wetlands, which are already affected by such runoff and in which water circulation is impeded by a backwater regime as a result of past flood control increases.

In order to minimize the present loss of wetlands in the Atchafalaya Basin as a result of river profile adjustments, the present diversion water must be at least maintained. However, the complete maintenance of present wetlands requires an increase of diverted discharges to offset the trend toward reduction in the extent, duration, and depth of flooding.

As a participant in the planning process for the development of a multiuse management plan for the Atchafalaya Basin, the U.S. Environmental Protection Agency is using the results of this study to make recommendations, enforceable through its responsibilities, to insure that Federal environmental requirements and objectives are sufficiently considered in the selection of a final plan.

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INTRODUCTION

The Atchafalaya Basin in south-central Louisiana is a large alluvial basin that has national significance as a multiple resource. It derives this significance principally from possessing high-quality habitats for fish and wildlife, being a semi-wilderness area of high recreational value, and functioning as a floodway for the lower Mississippi River. To meet the need for flood control, the U.S. Army Corps of Engineers (USCE) is considering hydrological modifications for the Basin. The Basin's present hydrological cycle and complex water circulation patterns support one of the world's most highly natural productive areas.

In response to a request by the Governor of Louisiana and a joint U.S. Congressional resolution, the U.S. Environmental Protection Agency (EPA), U.S. Army Corps of Engineers, and U.S. Department of the Interior (USDI) are conducting a water and land quality study in the Atchafalaya Basin. The study is assessing the potential impact of proposed hydrological modifications and developing alternative land and water management plans to accommodate flood flows and maintain an acceptable level of environmental quality for the Atchafalaya Basin. The purpose of the report is to consider from a multi-use management standpoint the operation of the Old River Control Project in the Atchafalaya Basin.

CONCLUSIONS

The following were concluded from this study:

1. Reducing the presently authorized discharges by the Old River Control Project will result in destruction, loss, and degradation of the wetlands in the Atchafalaya Basin and Red River backwater area and is in direct conflict with what is necessary for their preservation and enhancement.

2. Reducing maximum discharges at Simmesport to 260,000 ft^3/sec* would effectively remove those wetlands that are presently flooded for a period of 0 to 4 months from the aquatic ecosystem as a type habitat. This habitat represents as much as 36 percent of the wetland system of the Atchafalaya Basin Floodway below U.S. Highway 190.

3. Without stronger land use controls, a reduction in the annual extent of flooding would encourage new residential and agricultural development in present wetlands. This, in turn, would increase agricultural runoff into adjacent wetlands, which are already affected by such runoff and in which water circulation is impeded by a backwater regime as a result of past flood control measures.

*Because many of the available data used in preparing this report were in English units, metric units are not used throughout this report. Conversion factors are given in the Appendix.

RECOMMENDATION

It is recommended that the present diversion ratio by the Old River Control Project be at least maintained in order to minimize the present loss of wetlands as a result of river profile adjustments. However, the complete maintenance of present wetlands requires an increase of diverted discharge to offset the trend toward a reduction in the extent, duration, and depth of flooding.

BACKGROUND

The Atchafalaya River Basin, Louisiana, coincides with the natural basin formed by alluvial ridges that relate to present and former Mississippi River courses (Figure 1). The Basin extends inland from the Gulf of Mexico for a distance of 125 miles to the former confluence of the Mississippi River and Red River. Continuity of the Basin is only interrupted by an alluvial ridge, the Teche Ridge, that crosses the Basin at the latitude of Morgan City, Louisiana. Central to the Basin is the Atchafalaya River, which connects the Mississippi River and the Red River to the Gulf of Mexico and flows through the Teche Ridge at Morgan City where it becomes the Lower Atchafalaya River.

Until 1928, the entire Basin functioned as the Atchafalaya River flood plain and afforded a natural outlet for Mississippi and Red River floodwaters to the Gulf of Mexico. Since then major changes have evolved. In 1928 and 1956, respectively, Congress authorized the construction of a floodway through the Basin and the construction of control structures at Old River to regulate the diversion of Mississippi River flow into the Atchafalaya River (Figure 2). To provide a defined floodway, guide levees were constructed east of, west of, and parallel to the Atchafalaya River and at an average distance of 15 miles apart. Floodflows, as well as the annual overflow of the Atchafalaya River, thus became confined to the central part of the natural Basin as far south as the Teche Ridge. Through the ridge, flows are temporarily further confined to only the channels of the Lower Atchafalaya River and the constructed Wax Lake outlet until the guide levees terminate and water escapes the channels into adjacent wetlands and the Gulf of Mexico.

Despite the many adverse changes that have taken place as a result of indiscriminate use of the Atchafalaya Basin's water- and land-related resources, the Basin still constitutes a resource complex of exceptional recreational, ecological, and commercial significance. The floodway system above the Teche Ridge is one of the largest remaining alluvial flood-plain hardwood swamps in the United States. It contains more than 700,000 acres of hardwoods, nearly one-third of which are cypress-tupelo swamps, and 53,000 acres of water bodies (Figure 3). To this must be added the hardwood swamps of the Basin outside the floodway. Below the Teche Ridge, the Basin environment becomes one of freshwater and brackish water marshes and bays, where the present development of the Atchafalaya River delta is one of the most important processes from an environmental quality standpoint. This delta offers the potential development of a 300 mi^2 area of new wetlands by the year 2020 in a State where the loss of wetlands amounts to a staggering 16 mi^2 per year.

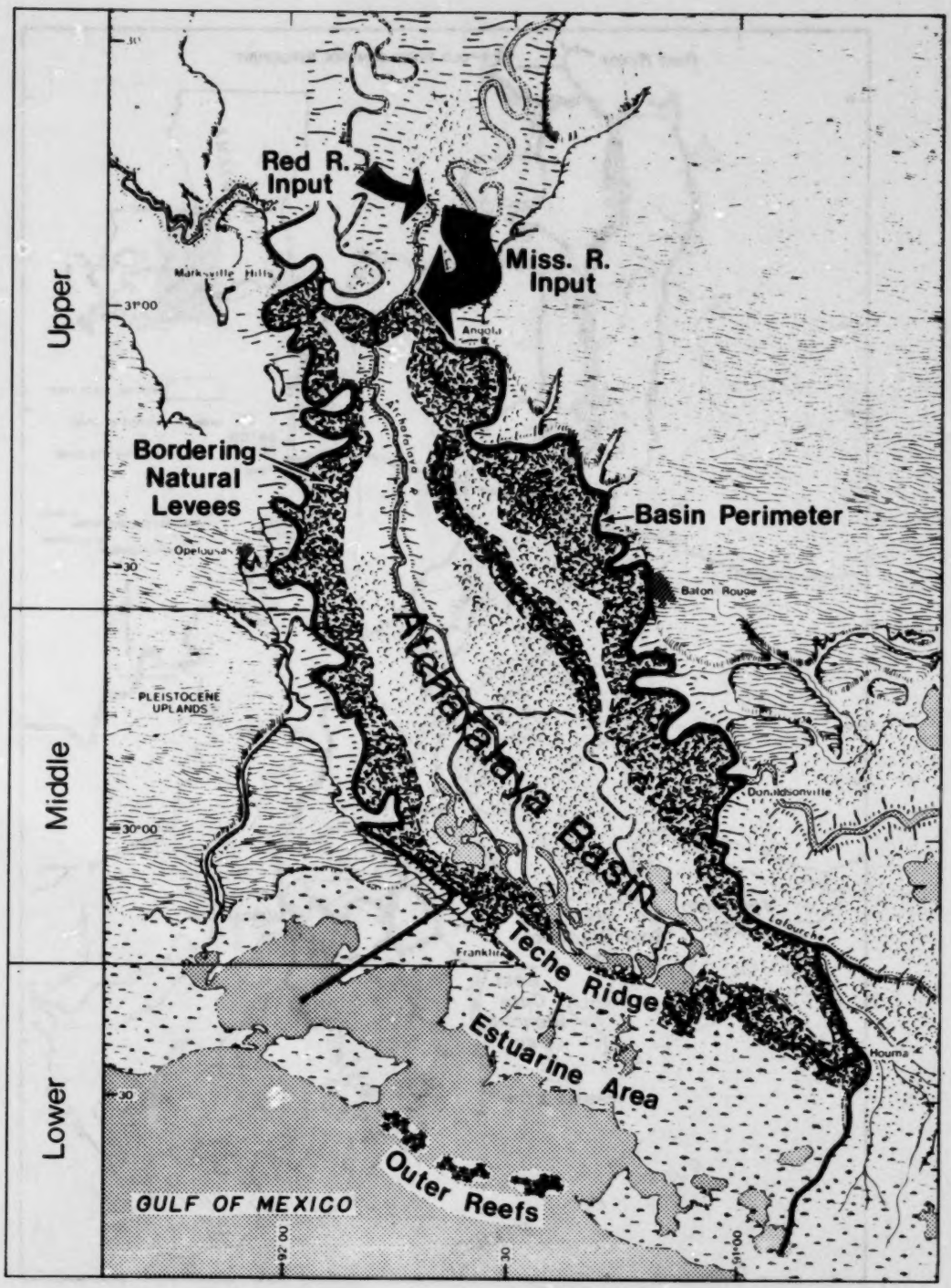


Figure 1. Physiographic setting of the Atchafalaya Basin, Louisiana.

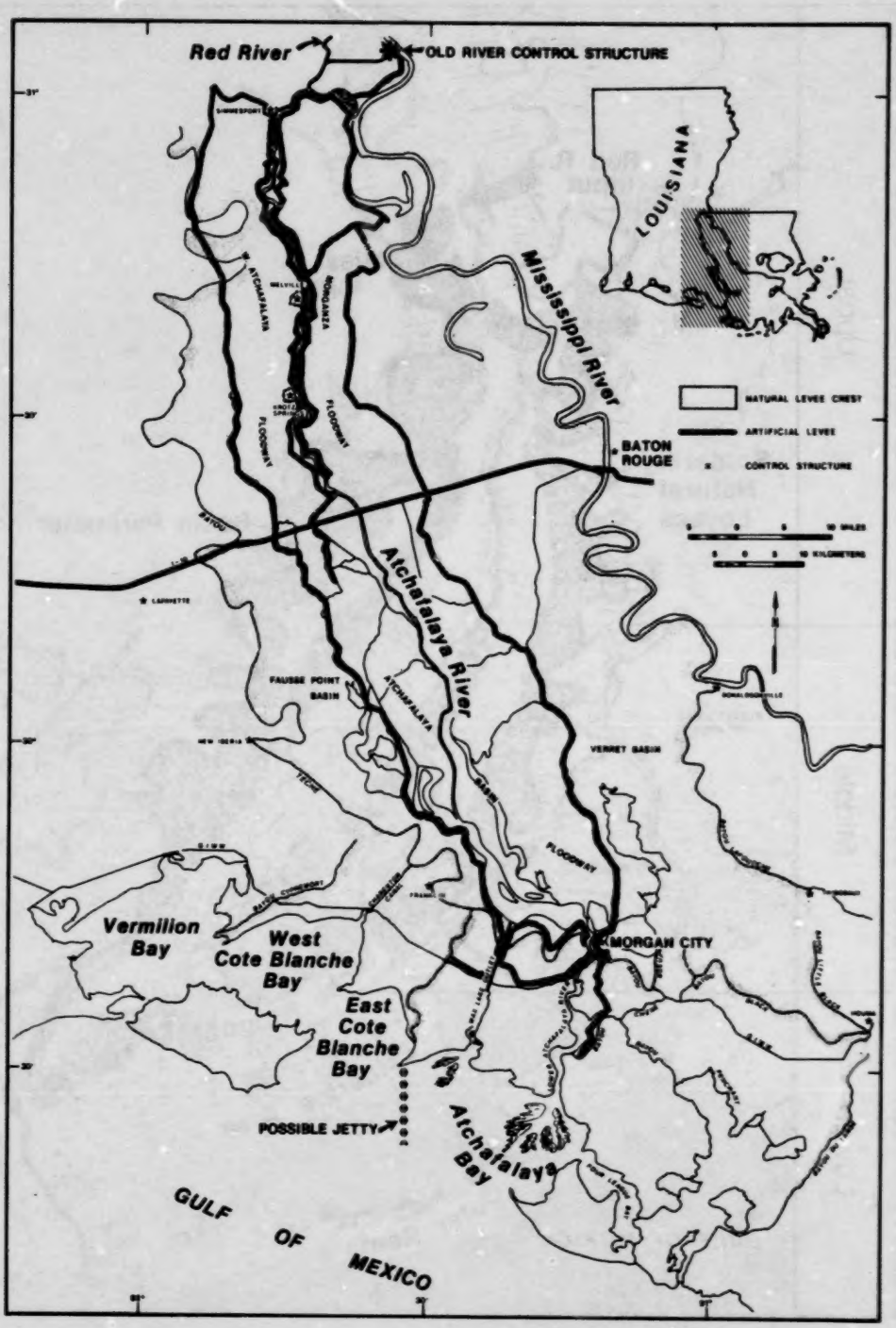


Figure 2. Levees of floodway system within the Atchafalaya Basin.

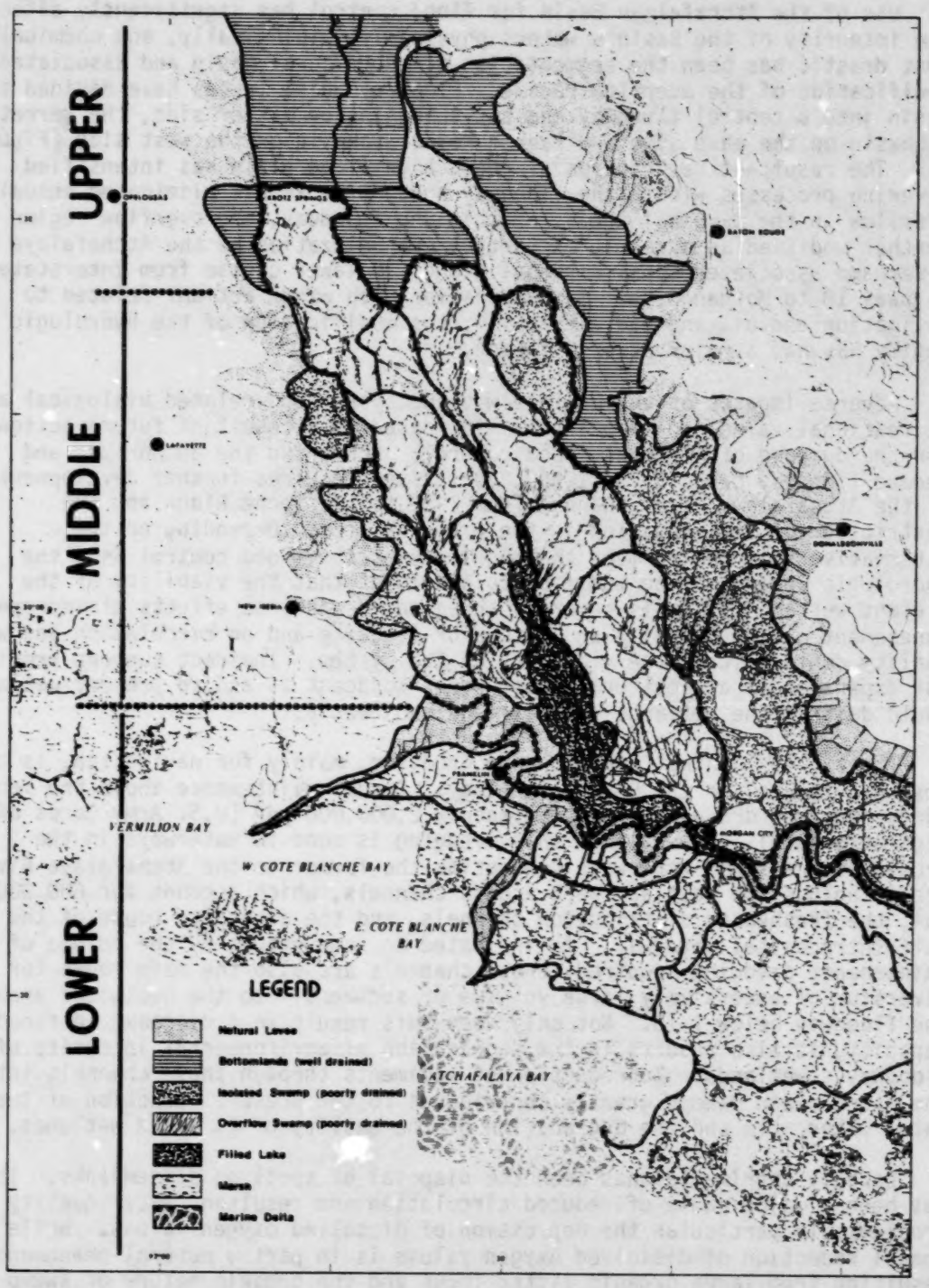


Figure 3. Natural environments and management-unit boundaries of the Atchafalaya Basin.

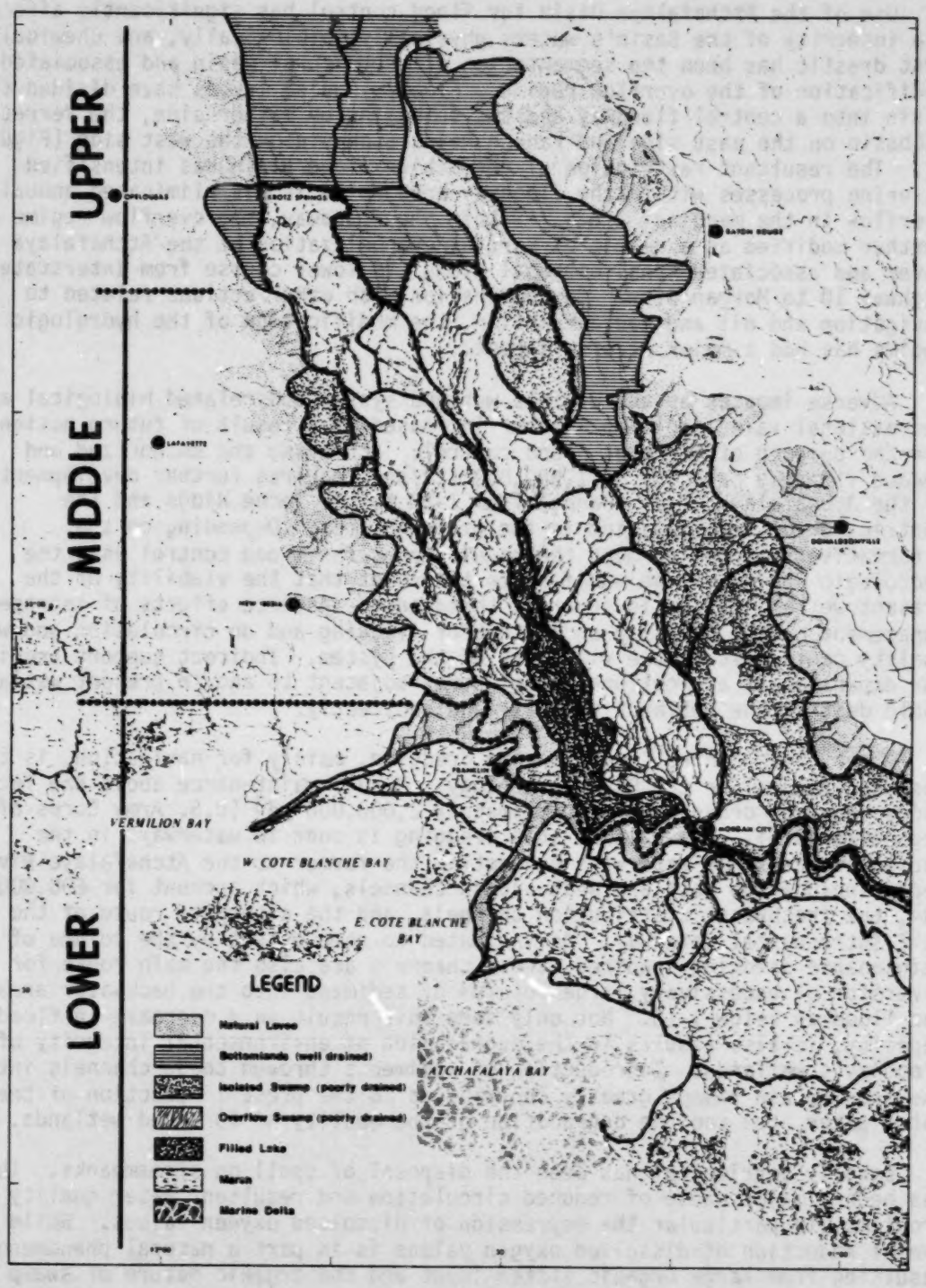


Figure 3. Natural environments and management-unit boundaries of the Atchafalaya Basin.

Use of the Atchafalaya Basin for flood control has significantly affected the integrity of the Basin's waters physically, biologically, and chemically. Most drastic has been the segmentation of the natural basin and associated modification of the overflow regime. Floodway guide levees have divided the Basin into a central floodway and two subbasins on either side, the Verret Subbasin on the east side and Fausse Point Subbasin on the west side (Figure 2). The resultant restriction of the active flood plain has intensified riverine processes within the floodway area while it has eliminated annual overflow in the marginal areas. Within the floodway, the overflow regime was further modified as a result of partial channelization of the Atchafalaya River and associated spoil disposal along its lower course from Interstate Highway 10 to Morgan City. In combination with other actions related to navigation and oil and gas extraction, the modification of the hydrologic regime has had a major adverse impact.

Adverse impacts on the Basin's wetland system and related biological and recreational value could be further increased as a result of future actions for the purpose of improved flood control. Achieving the authorized and needed floodway capacity of 1,500,000 ft^3/sec requires further development of the Atchafalaya River channel from I-10 to the Teche Ridge and the restriction of sedimentation in the overbank area. Depending on the alternative selected to meet the requirements for flood control use, the hydrologic regime may be modified to the point that the viability of the present wetland system is severely threatened. Adverse effects of improper management on the duration and extent of flooding and on circulation and water quality could destroy the viability of the system. Indirect support provided for expansion of agricultural development adjacent to and in present wetlands could destroy the wetlands directly and indirectly.

After flood control, maintenance dredging, mainly for navigation, is the most detrimental to the Basin's ecology. Annual maintenance above the Teche Ridge requires dredging of approximately 2,000,000 yd^3 (U.S. Army Corps of Engineers 1975). One-half of this dredging is done in waterways in the backwater areas and waterways connecting the former to the Atchafalaya River. These include the east and west access channels, which account for 600,000 yd^3, the freshwater distribution channels, and the alternate route of the Gulf Intracoastal Waterway. As indicated to some extent by the volume of maintenance dredging required, these channels are also the main route for the diversion of excessively large volumes of sediment into the backwater area of the floodway below I-10. Not only does this result in a decrease in floodway capacity, it also results in the degradation of environmental integrity of the floodway's wetlands. Introduction of sediments through these channels into the flood-plain swamps greatly contributes to the present reduction of the total water area and the degradation of the quality of forested wetlands.

Equally detrimental has been the disposal of spoil on streambanks. This has been a major cause of reduced circulation and resultant water quality problems, in particular the depression of dissolved oxygen values. While annual reduction of dissolved oxygen values is in part a natural phenomenon resulting from large organic litter input and the organic nature of swamp sediments, at present the oxygen values in large swamp areas as well as

streams are depressed for periods in excess of one month to levels where the water can no longer support fishes and other aquatic life.

In the Lower Atchafalaya River connecting Morgan City and the surrounding industrial development to the Gulf of Mexico, provisions for navigation are creating a serious degradation of the environment. Because this navigation route traverses the area of the most rapid growth of the Atchafalaya Delta, maintenance of the authorized navigation channel requires annual dredging. This action channelizes water and sediment through the active delta to deeper water and thus reduces the potential for valuable development of new wetlands.

The direct and indirect support for agricultural development in the Basin, inside and outside the floodway, is creating destructive pressure on the systems in the Basin. Expansion of agricultural development is facilitated by a number of processes and actions. Within the floodway, enlargement of the Atchafalaya River channel has resulted in a lowering of annual flood stages above I-10 thus reducing backwater flooding in the upper floodway. Since that area is already protected from direct river overflow by levees within the floodway along the Atchafalaya River, the reduced backwater flooding has allowed the expansion of agricultural development through the clearing of flood-plain forests. Application has been received by the United States Soil Conservation Service (USSCS) for planning of a small watershed project involving 165,000 acres. Similarly, agricultural expansion takes place along and into the swamp forests of the Basin outside the floodway with support of a number of USSCS watershed projects.

The potential for further expansion of agricultural development and habitation of the floodway is increased by the consideration of reducing diversion of waters from the Mississippi River into the Atchafalaya River during annual flood stages. This plan is considered for the purpose of enhancing agricultural development in the flood plain of the Red River immediately north of the floodway. Such reduction in flows would equally affect the backwater stages in the northern part of the floodway, thus providing for increased flood-plain development, and would reduce annual overflow in the lower floodway, affecting the hydrologic regime of the wetlands there.

Concern for the protection of the environment has been growing, as has concern that the flood control value of the floodway is becoming increasingly less than it should be. On June 11, 1968, and March 23, 1972, the United States Senate Committee on Public Works, and on June 14, 1972, the United States House of Representatives Committee on Public Works, adopted resolutions concerning management and use of the water and related land resources of the Atchafalaya River Basin. These resolutions directed the USCE to determine whether, in light of changed conditions, modifications to the operation of the Old River Control Project are warranted and to review, in cooperation with other agencies including the EPA, the report on the Mississippi and Tributaries Project, House Document 308, 88th Congress, and other pertinent reports, with a view to developing a comprehensive plan for the management and preservation of the water and related land resources of the Atchafalaya River

Basin, Louisiana. As directed, this would include provisions for reduction of siltation, improvement of water quality, and possible improvement of the area for commercial and sport fishing.

In response to the Senate and House resolutions, the Atchafalaya Basin Land and Water Resources Interagency Study was initiated in 1972. Participants are the USCE, EPA, USDI, and State of Louisiana. As a participant in the planning process, the EPA is in a position to make recommendations, enforceable through its responsibilities, to insure that Federal environmental requirements and objectives are sufficiently considered in the selection of a resource management plan. Objectives of the EPA in the Atchafalaya Basin include: 1) land use requirements to control agriculturally related nonpoint sources of pollution (Federal Water Pollution Control Act Amendment (FWPCAA), 1972, Sec. 208); 2) the 1983 goal of water quality, which provides for the protection and propagation of fish, shellfish, and wildlife and provides for recreation in and on the water, and the restoration and maintenance of the chemical, physical, and biological integrity of the Nation's water (FWPCAA, 1972, Sec. 101); 3) avoidance of degradation in any way of waters that in their existing condition could be used for sport fishing with degradation reducing their value for that use; 4) reduction of the adverse impact of spoil disposal on fishery, wildlife, or recreational areas (FWPCAA, 1972, Sec. 404); 5) monitoring of the discharge of dredged material in wetlands; 6) the avoidance of long- and short-term adverse impacts associated with destruction and modification of wetlands (Exec. Order 11990); 7) the avoidance of direct or indirect support of new construction in wetlands (Exec. Order 11990, Federal Register, 1977); 8) the avoidance, to the extent possible, of long- and short-term adverse impacts associated with the occupancy and modification of flood plains (Exec. Order 11988, Federal Register, 1977); 9) the avoidance of direct or indirect support of flood-plain development whenever there is a practicable alternative (Exec. Order 11988); and 10) the avoidance of discharge of material that would have an unacceptable adverse effect on municipal water supplies, shellfish beds, and fishery, wildlife, or recreational areas (Public Law 92-500, Sec. 404, C).

OLD RIVER CONTROL PROJECT

On July 13, 1963, the Old River Control Project was placed in operation (Figure 4). The Old River Control Complex is a part of the Flood Control, Mississippi River and Tributaries (FC,MR&T) Project, a comprehensive flood control project dating from the Flood Control Act of 1928 and extending from Cape Girardeau, Missouri, to the Head of Passes below New Orleans, Louisiana. One of the essential features of the FC,MR&T Project is the continued use of the Atchafalaya Basin as a floodway. Previous to the Old River Control Project, Mississippi River waters entered the Atchafalaya Basin via a short channel known as Old River, which connected the Mississippi and Atchafalaya Rivers. A steady increase was noted in the volume of water flowing from the Mississippi River into the Atchafalaya River, and by the early 1950's it became apparent that, in the absence of any intervention by man, the Mississippi River would use the Old River connection to change its course to that of the Atchafalaya River. To prevent such an occurrence, Congress, by the Flood Control Act of 1954 (P.L. 780, 83rd Congress), modified the FC,MR&T Project by authorizing the Old River Control Project to regulate the flow of water from the Mississippi River into the Atchafalaya River.

The Old River Control Project is located on the right descending bank of the Mississippi River about 50 miles northwest of Baton Rouge, Louisiana. Principal features of the Old River Control Project (see Figure 4) are: two mechanically operated control structures, designated the low sill structure and the overbank structure; an inflow channel from the Mississippi River to the low sill control structure; an outflow channel connecting the low sill control structure with Red River; a lock for navigation connecting the Mississippi and Old Rivers; forebay and tailbay channels for the lock; an earthen dam closing Old River; enlargement and extension of main line Mississippi River levees; and bank stabilization as required in the Red and Atchafalaya Rivers between the outflow channel and the vicinity of Simmesport.

The authorizing legislation for the Old River Control Project made it obligatory that flow and sediments between the Mississippi and Atchafalaya Rivers be in the proportions that occurred in 1950. In 1950 the Atchafalaya River carried 30 percent of the latitude flow and the lower Mississippi River carried 70 percent. Latitude flow is the total flow of the Mississippi and Red Rivers at the latitude of, but just above, the Old River Control Project. At Mississippi River stages (at Old River Control Project) of 52.0 feet and below, the overbank structure cannot be operated and all diversion is regulated through the low sill structure. At stages above 52.0 feet, both structures are normally operated.

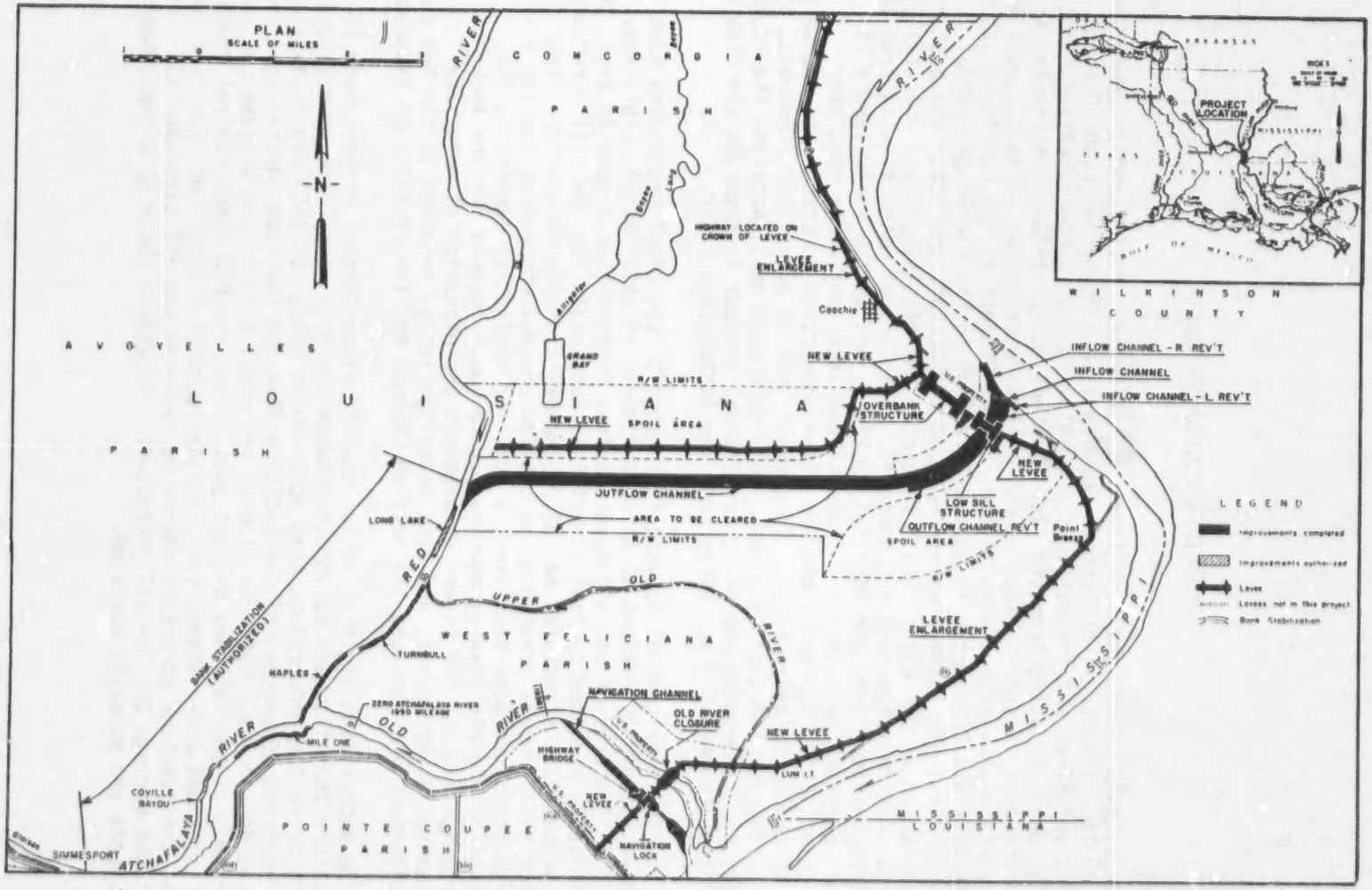


Figure 4. Old River Control Project.

The volume of water that is allowed through the control structures determines the character of the entire Atchafalaya Basin Floodway complex. Because the channel leading from the control structures to the head of the Atchafalaya River also receives the waters from the Red River, the volume of water diverted through the structures not only controls the annual stage variation and flooding in the Atchafalaya Basin Floodway complex but, through backwater flow, also greatly influences the stages in the Red River backwater area. The Old River Control Project therefore plays a vital role in controlling the use of water and related land resources in both the Atchafalaya Basin Floodway complex and the Red River backwater area.

The resource uses that are affected most by the amount of discharge diverted are commercial and sport fisheries and recreation (affected because the amount of discharge is critical to aquatic ecosystems), agriculture (because the amount of discharge controls flooding during the spring planting season), silviculture (because the amount of discharge controls flooding during the growing season), and flood control (because the amount of discharge has an effect on the size of the Atchafalaya Basin main channel). It can be seen that the percentage of the Mississippi River's water that is diverted by the Old River Control Project is a factor that affects every use and value in the Basin.

THE OVERFLOW REGIME

The process most important to the ecology of the Atchafalaya Basin is the annual flooding and dewatering of the Atchafalaya River flood plain within the floodway guide levees. This annual inundation by flood waters constitutes an energy subsidy that increases the swamp's productivity (Odum 1969) and makes the overflow swamp environment one of the most diverse and productive of our native environments (Wharton 1970). The entire system is adapted to and based upon seasonal fluctuations of water level. Therefore, the relationship between the hydrologic regime and the environment must be understood. Without this understanding, it is impossible to evaluate the impacts of activities or changes in the Basin, and it is impossible to formulate a multiuse management plan.

A number of studies have been undertaken on this subject since 1972 by the EPA and U.S. Fish and Wildlife Service (FWS). From these studies has evolved a basic understanding of the role the flooding regime plays in determining diversity, type, and quality of the Basin's environments and of the requirements for maintaining and restoring environmental integrity.

The diversity of habitats and habitat distributions as they exist at present are controlled primarily by the extent, duration, depth, and time of flooding. (The second major controlling factor is the rate of deposition of inorganic sediments.) While the average time of flooding has been relatively stable because it is controlled by the April discharge peak of the Atchafalaya River, the duration, depth, and extent of flooding are variable in time and space. They are variable in time because sedimentation within the floodway continues to elevate the flood plain relative to the Atchafalaya River stages. They are variable in space because of topographic variation within the floodway and variation in stage fluctuations along the Atchafalaya River.

The spatial variation in the floodway regime means a variation in habitats, hydrologic requirements, and suitability for certain uses. To deal with this variation, the floodway has been divided in a former study (van Beek et al. 1977) into a number of subbasins that are amenable to surface-water management. These subbasins can be considered as management units, and their locations and names can be seen on Figure 5. The temporal variation means that surface-water management must not only meet present requirements for maintenance and restoration of environmental quality within management units but also counter or redirect present trends that are undesirable.

Duration, depths, and extent of flooding, and therefore the distribution of habitats in the Atchafalaya Basin Floodway complex, show two trends. The first is a north-to-south trend from mixed hardwoods to cypress-tupelo swamps

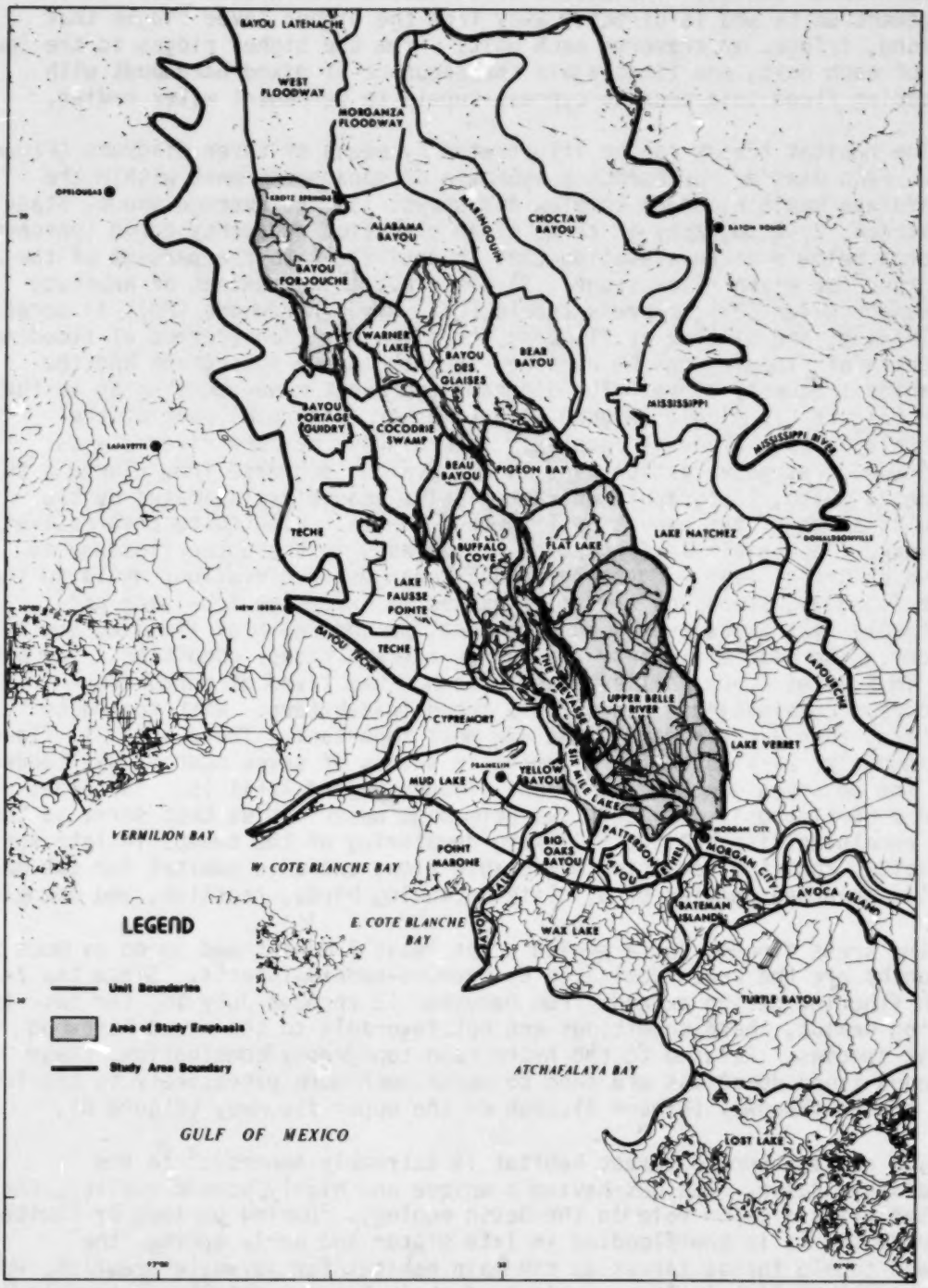


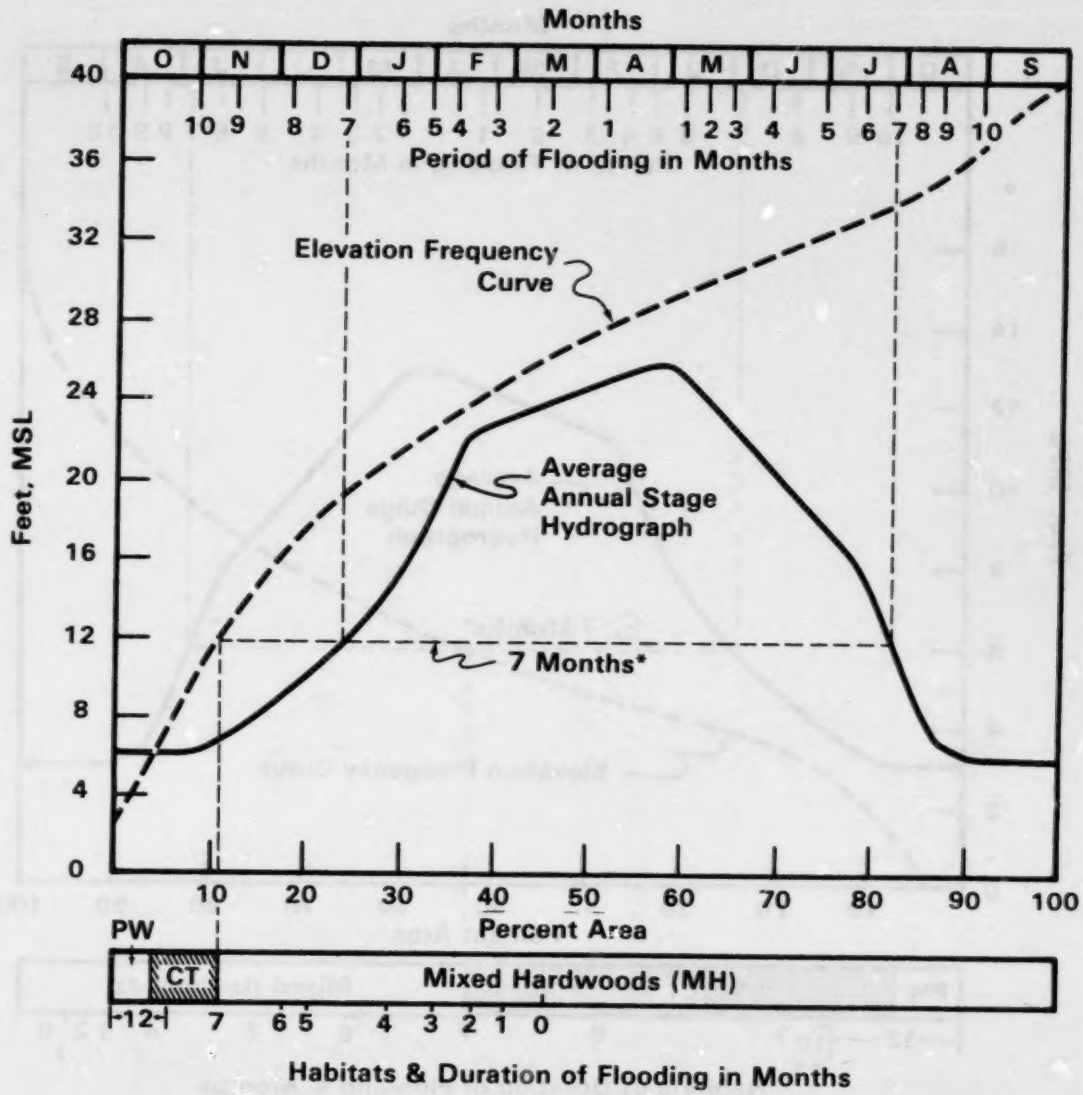
Figure 5. Division of the Atchafalaya Basin into management units on the basis of natural environment and human use.

and open water bodies. The second trend occurs within individual subbasins or management units and is directed away from the higher levee ridges that surround, fringe, or traverse each unit. From the higher ridges to the lower part of each unit, one finds again the sequence of mixed hardwoods with increasing flood tolerance to cypress-tupelo to permanent water bodies.

The habitat trends can be illustrated by means of three diagrams (Figures 6-8). Each diagram represents a subbasin or management unit within the Atchafalaya Basin Floodway complex and shows: 1) the average annual stage hydrograph; 2) topography in terms of an elevation frequency curve (percent of the area below a given elevation that is equivalent to the percent of the area submerged for given river stage); 3) distribution and extent of habitats (permanent water (PW), cypress-tupelo (CT), mixed hardwoods (MH); 4) duration of flooding; and 5) time of flooding for given duration (period of flooding). The depth of flooding can be obtained from the stage hydrograph and the elevation frequency curve. The diagrams represent management units in the upper (Figure 6), middle (Figure 7), and lower (Figure 8) part of the Atchafalaya Basin Floodway complex. Accordingly, maximum river stages, amplitude of stage variation, and land elevation decrease from Figure 6 to Figure 7. Also, topographic characteristics change as indicated by the changing shape of the elevation frequency curves. Related to progressively southward flood-plain sedimentation, topography in the upper floodway is marked by broad levee ridges and gradual changes in elevation, while in the lower floodway, subbasins are still marked by extensive low-lying and relatively flat areas over which the duration and depth of flooding are fairly uniform. The middle floodway represents a transitional condition. The bottom line in Figures 6 and 7 illustrates also how the trend of topography-hydrograph combinations results in a trend in habitats. With regard to habitats, four average conditions are most important. These are: 1) flooded continuously; 2) flooded for a period in excess of seven months; 3) flooded from one to seven months; and 4) not flooded beyond April 15. The areas flooded continuously represent the permanent water bodies that serve as the only remaining fish habitat following dewatering of the swamps in late spring, as habitat for fish requiring measurable flow, and as a habitat for the many aquatic-oriented species of wildlife including birds, reptiles, and mammals.

The areas flooded for a period of at least 7 months and up to as much as 12 months are the areas dominated by cypress-tupelo forests. Since the 7-month flooding period extends from December 15 through July 15, far into the growing season, these conditions are not favorable to the mixed hardwood forest species. Related to the hydrograph-topography combination, these extended flood durations are seen to occur much more extensively in the lower part of the floodway (Figure 8) than in the upper floodway (Figure 6).

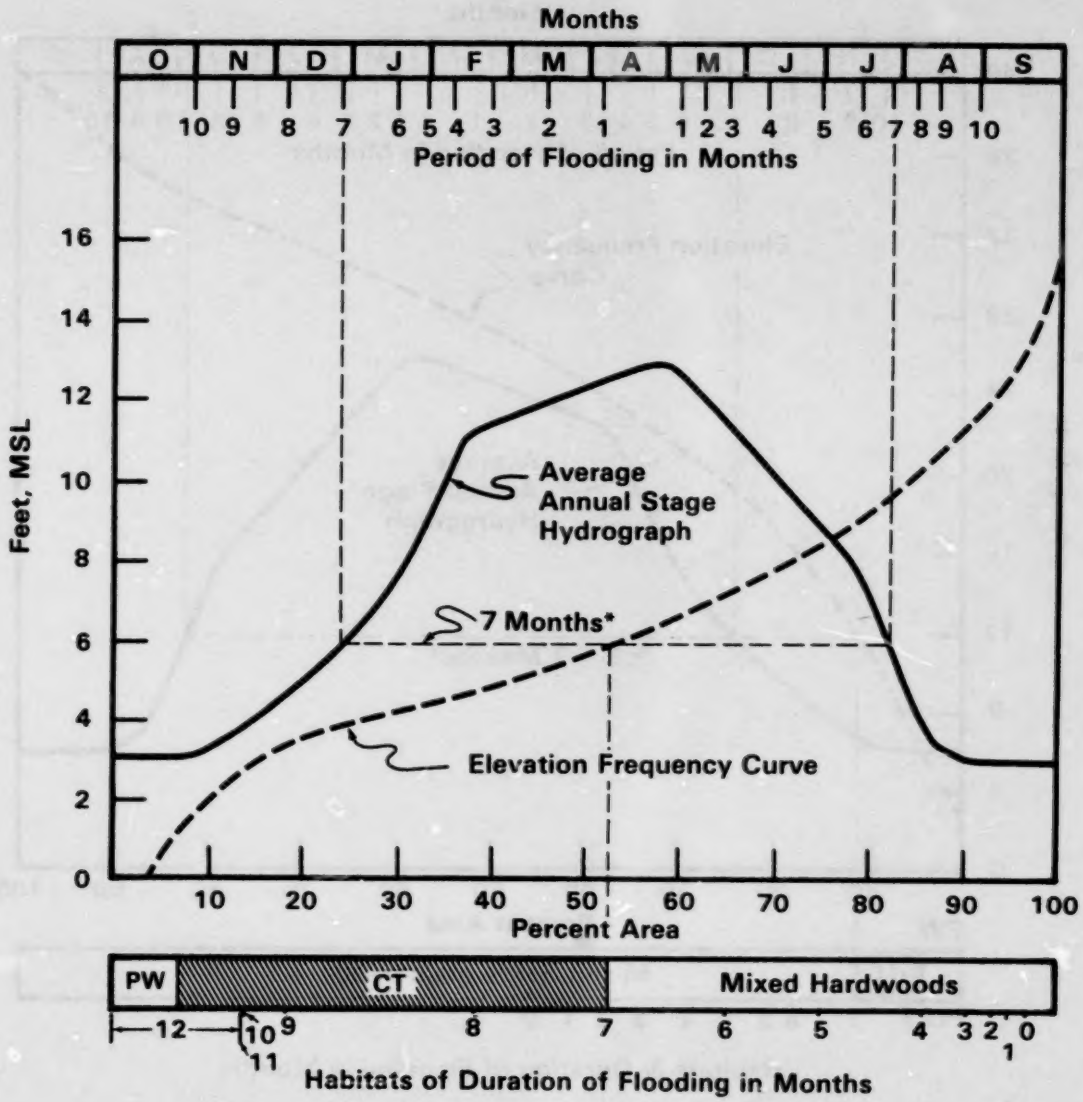
The cypress-tupelo forest habitat is extremely important in the Atchafalaya Basin. Besides having a unique and highly scenic quality, the habitat plays a major role in the Basin ecology. During periods of limited water depth, as in the flooding in late winter and early spring, the cypress-tupelo forest serves as the main habitat for juvenile crawfish, which are the direct link in the aquatic food chain between detritus material and predatory fishes and aquatic-oriented wildlife. Following an increase in



(PW = permanent water; CT = cypress-tupelo)

*Seven months is the minimum duration of flooding for areas to be dominated by cypress-tupelo forests

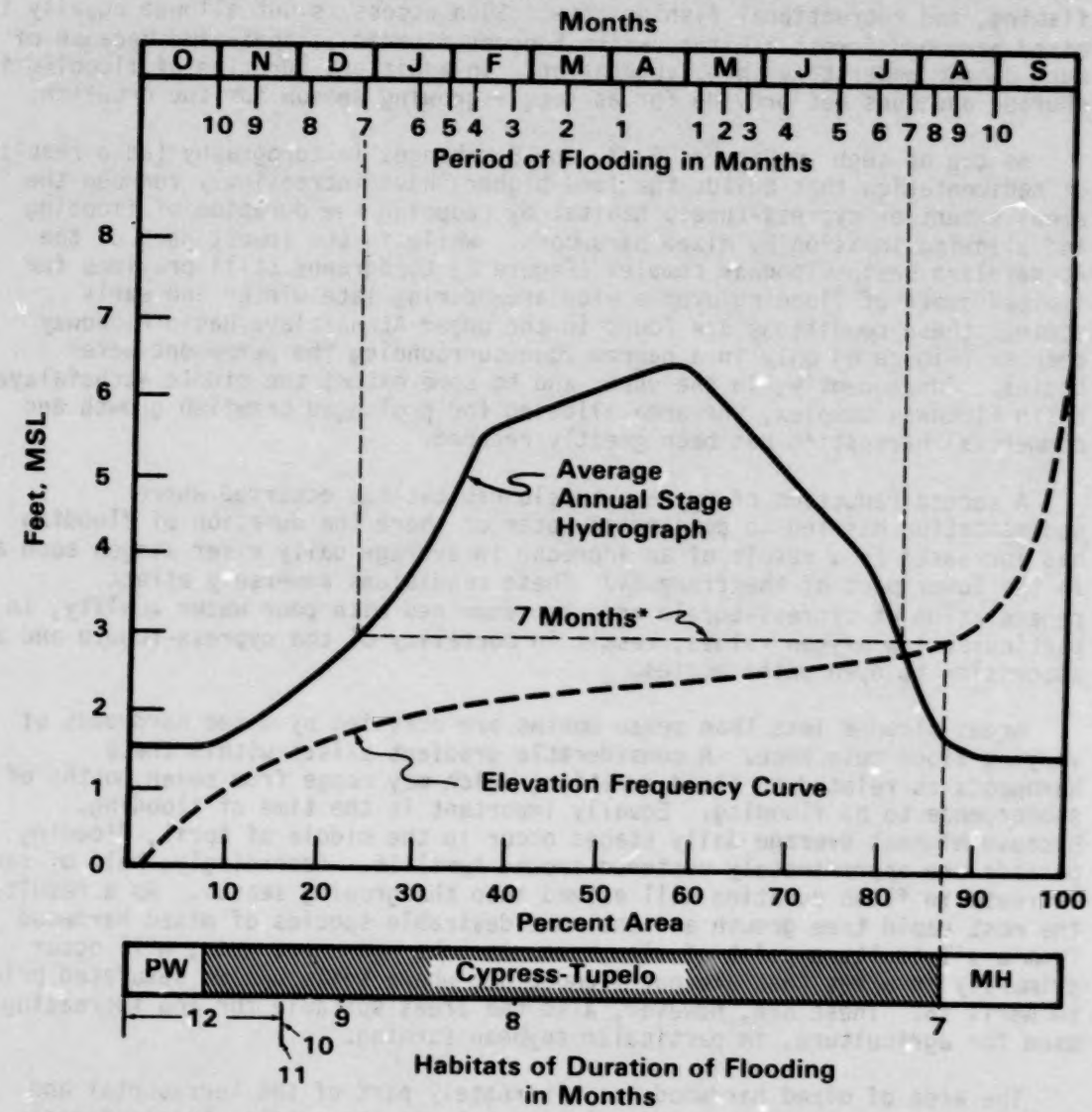
Figure 6. Schematic representation of topography, overflow regime, and associated habitats in management units of the upper floodway.



(PW = permanent water; CT = cypress-tupelo)

*Seven months is the minimum duration of flooding for areas to be dominated by cypress-tupelo forests

Figure 7. Schematic representation of topography, overflow regime, and associated habitats in management units of the middle floodway.


Months
O N D J F M A M J J A S
10 9 8 7 6 5 4 3 2 1 1 2 3 4 5 6 7 8 9 10
Period of Flooding in Months
Feet, MSL
0 1 2 3 4 5 6 7 8
Average
Annual Stage
Hydrograph
7 Months*
Elevation Frequency Curve
10 20 30 40 50 60 70 80 90 100
Percent Area
PW
Cypress-Tupelo
MH
12 11 10 9 8 7
Habitats of Duration of Flooding
in Months

(PW = permanent water; MH = mixed hardwoods)

*Seven months is the minimum duration of flooding for areas to be dominated by cypress-tupelo forests

Figure 8. Schematic representation of topography, overflow regime, and associated habitats in management units of the lower floodway above Teche Ridge.

water depth during March and April, the cypress-tupelo swamp becomes a major feeding area for adult and juvenile fishes. At that time the increased water depths also allow access for extensive commercial crawfishing, commercial fishing, and recreational fishing uses. Such access is not allowed equally in mixed hardwood forest habitat, which becomes flooded at that time because of much denser understory shrub vegetation. In addition, duration of flooding is shorter and does not provide for as long a growing season for the crawfish.

As can be seen in Figures 6, 7, and 8, changes in topography (as a result of sedimentation that builds the land higher) have increasingly reduced the areal extent of cypress-tupelo habitat by reducing the duration of flooding and allowing invasion by mixed hardwoods. While in the lowest part of the Atchafalaya Basin Floodway complex (Figure 8) topography still provides for limited depth of flooding over a wide area during late winter and early spring, these conditions are found in the upper Atchafalaya Basin Floodway complex (Figure 6) only in a narrow zone surrounding the permanent water bodies. Consequently, in the upper and to some extent the middle Atchafalaya Basin Floodway complex, the area allowing for prolonged crawfish growth and commercial harvesting has been greatly reduced.

A second reduction of cypress-tupelo habitat has occurred where sedimentation has led to ponding of water or where the duration of flooding has increased as a result of an increase in average daily river stages such as in the lower part of the floodway. These conditions adversely affect regeneration of cypress-tupelo and when combined with poor water quality, in particular low oxygen values, result in mortality of the cypress-tupelo and a succession to open water bodies.

Areas flooded less than seven months are occupied by mixed hardwoods of varying flood tolerance. A considerable gradient exists within these hardwoods as related to flood duration, which may range from seven months of submergence to no flooding. Equally important is the time of flooding. Because highest average daily stages occur in the middle of April, flooding periods are approximately centered around April 15. Accordingly, half of each increase in flood duration will extend into the growing season. As a result, the most rapid tree growth and the more desirable species of mixed hardwood from a silviculture point of view, such as oaks and sweet gums, will occur primarily in areas that are not flooded but where soils become saturated prior to April 15. These are, however, also the areas suitable for and increasingly used for agriculture, in particular soybean farming.

The area of mixed hardwoods is alternately part of the terrestrial and aquatic ecosystem as a transitional zone between the cypress-tupelo forests and the oak-sweet gum forest type. Accordingly, this transitional zone serves both the aquatic and terrestrial species. In spring and early summer, these mixed hardwood swamps serve as feeding areas for crawfish, nursery and feeding areas for young-of-year and adult fishes, respectively, and habitat for aquatic wildlife. The area is of additional major importance in that the dewatering process traps many fishes and other aquatic species, thus providing important food and feeding areas for wading birds and mammals; the floodway's

swamps contain a number of wading-bird rookeries. During late spring, summer, and fall the swamp mixed hardwoods serve as feeding area and shelter for terrestrial wildlife such as deer, rabbit, etc.

A number of complex ecological relationships exist between the three types of habitats with regard to their importance to Basin productivity and use. These relationships in turn dictate certain requirements necessary to maintain overall integrity of the floodway environment. One major relationship is that between permanent water bodies and the periodically flooded areas. The latter provide for a large periodic increase in feeding and nursery area for many aquatic species. However, it must be realized that many of these species will be confined to what water bodies are left upon dewatering of the swamps in the summer and early fall. Consequently, full utilization of the periodically flooded swamp forest within the aquatic ecosystem requires a certain area of permanent water bodies with physical and chemical characteristics that meet habitat requirements.

Similarly, the periodically dewatered swamp can be fully utilized by terrestrial wildlife only if a sufficient flood-free area remains during the spring high-water period and if this flood-free area meets habitat requirements.

Present areal and percentage distribution of the three major flooding conditions are given in Table 1 for the management units within the Atchafalaya Basin Floodway (based on data in van Beek et al. 1977).

While it is not presently known what proportions between permanently flooded, periodically flooded, and flood-free areas represent the most desirable conditions from an aquatic point of view, the table points out certain aspects of the present environment that are important. First, it shows that 84 percent of the Atchafalaya Basin Floodway is subject to annual overflow, while part of the remaining 16 percent has periodically saturated soils. It is safe to say, therefore, that at least 90 percent of the Atchafalaya Basin Floodway can be thus classified as a wetland environment. Within given management units, the area flooded annually varies from 98 percent in the Upper Belle River unit to 61 percent in the Warmer Lake unit. From these observations, it must be concluded that most of the periodically flooded lands in the Atchafalaya Basin Floodway serve aquatic and aquatic-oriented species rather than the terrestrial biota. Consequently, availability of permanent water bodies of sufficient size and quality to serve as aquatic habitat during low-water months is of major importance.

A second observation that can be made from Table 1 is that in the Atchafalaya Basin Floodway below U.S. Highway 190 only a limited area, 16 percent, is suitable for growth of high-quality timber hardwood. In most areas, periodic flooding together with the occurrence of maximum water levels at the beginning of the growing season result in lesser quality hardwoods from a timber point of view and in slow growth rates. It is furthermore evident that those mixed hardwood forests not subject to periodic overflow are of extreme importance as terrestrial wildlife habitats during high-water season, since they occupy a small area relative to the habitat that is only periodically available.

TABLE 1. AREAL AND PERCENTAGE DISTRIBUTION OF FLOODING DURATION IN MANAGEMENT UNITS OF THE ATCHAFALAYA BASIN FLOODWAY

Management Unit	Area (km^2)	Percent and Area of Unit Subject to Given Duration of Flooding (Months)													
		12		11-12		8-11		4-8		1-4		0-1		0	
		%	km^2	%	km^2	%	km^2	%	km^2	%	km^2	%	km^2	%	km^2
Bayou des Glaises	259	2	5	1	4	3	8	27	70	34	88	2	6	30	78
Bayou Fordoche	319	42	134	1	3	12	39	15	48	5	15	1	1	25	80
Warner Lake	88	0	0	3	3	4	3	40	35	9	8	5	4	39	34
Cocodrie Swamp	155	15	23	1	1	6	9	23	35	27	42	3	5	27	42
Beau Bayou	85	10	9	1	1	7	6	33	28	29	25	5	4	12	10
Pigeon Bay	153	10	15	1	1	10	16	34	52	26	40	6	9	13	20
Buffalo Cove	236	23	54	1	2	11	27	36	85	14	34	1	3	13	31
Flat Lake	181	37	67	10	19	18	33	21	38	8	15	2	4	3	5
Crevasse	142	29	41	1	2	1	2	18	25	25	35	4	6	22	31
Upper Belle River	497	43	214	5	27	13	65	32	160	4	21	1	1	2	10
Total A.B. Floodway	2115	27	562	3	63	10	208	27	576	15	323	2	43	15	341
Total A.B. Floodway	2115	27	562	13%		271 km^2		44%		942 km^2				15%	341 km^2

FLOOD CONTROL

The Atchafalaya Basin is a vital component in the flood control plan for the Lower Mississippi River and tributaries. Its planned function in accommodating part of the project design flood is illustrated in Figure 9. This flood is estimated to have a magnitude of 3,030,000 ft^3/sec at the latitude of the Old River Control Project, of which 310,000 ft^3/sec is accommodated by storage in channel and overbank areas. Thus a discharge of 2,720,000 ft^3/sec must be conveyed to the Gulf of Mexico.

The project plan provides for passage of 1,500,000 ft^3/sec by the Mississippi River and Bonnet Carre Spillway past the urban-industrial area including the cities of Baton Rouge and New Orleans. Thus 1,220,000 ft^3/sec must be accommodated by the Red River backwater area and the Atchafalaya Basin Floodway complex. These must, however, also accommodate a projected inflow of 350,000 ft^3/sec from the Red River and tributaries. Therefore the total accommodation by the Red River backwater area and the Atchafalaya Basin Floodway complex must be 1,570,000 ft^3/sec.

The project plan calls for diversion from the Mississippi River of 620,000 ft^3/sec into the Red River backwater area through the overbank and low sill control structure of Old River and of 600,000 ft^3/sec directly into the Atchafalaya Floodway complex through the Morganza control structure. Of the combined Mississippi River and Red River inflows into the Red River backwater area, 40,000 ft^3/sec is accommodated by storage, leaving 930,000 ft^3/sec to be routed into the Atchafalaya Basin Floodway. Of this amount, a discharge of 680,000 ft^3/sec is to enter through the main channel of the Atchafalaya River and 250,000 ft^3/sec is to pass through the West Atchafalaya Floodway by natural or artificial crevassing of the so-called fuse plug levee. With a projected storage capacity of 30,000 ft^3/sec, the Atchafalaya Basin Floodway complex must convey a flow of 1,500,000 ft^3/sec. Of this flow, 300,000 ft^3/sec is to leave the floodway through the Wax Lake outlet and 1,200,000 ft^3/sec through the Lower Atchafalaya River past Morgan City.

The Atchafalaya Basin Floodway complex presently meets neither the required conveyance capacity of 1,500,000 ft^3/sec nor the required storage capacity of 30,000 ft^3/sec. Deficiencies occur primarily in the Atchafalaya Basin Floodway from the leveed portion of the Atchafalaya River main channel down to the Gulf of Mexico. The extent of these deficiencies was brought out during the 1973 Mississippi River flood when the Atchafalaya Basin Floodway was used to its greatest capacity. The largest introduction of water occurred on May 16, 1973, when 763,000 ft^3/sec was discharged from the Red River backwater area through the Atchafalaya Basin main channel and 106,000 ft^3/sec from the Mississippi River through the Morganza structure (U.S. Army

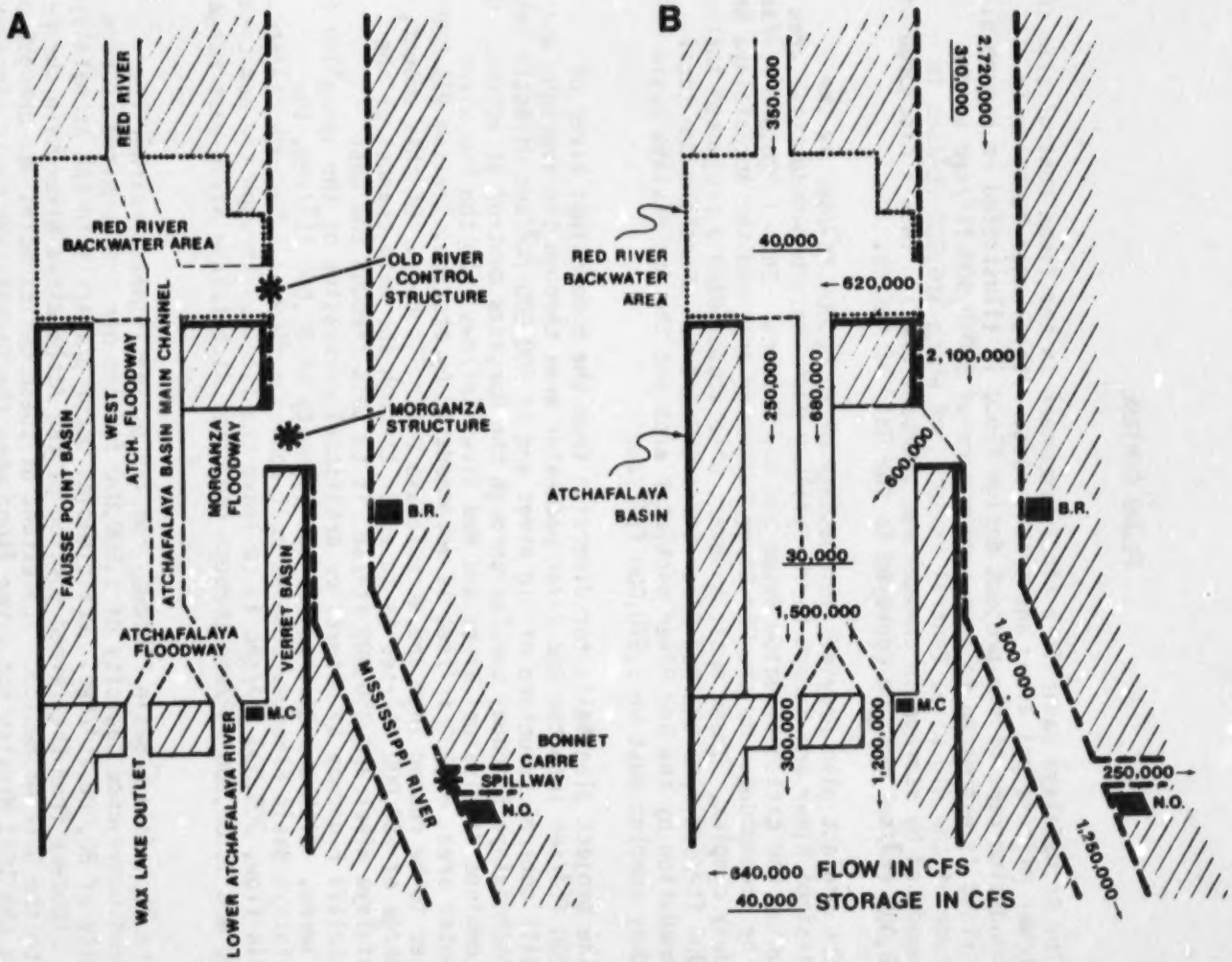


Figure 9. Atchafalaya Basin Floodway system. (A) Major elements. (B) Proposed project flood distribution (U.S. Army Corps of Engineers 1973).

Corps of Engineers 1975). Maximum total introduction thus was 869,000 ft^3/sec. At that date, outflows through Wax Lake outlet and the Lower Atchafalaya River attained magnitudes of 257,000 and 640,000 ft^3/sec, respectively, or a total of 897,000 ft^3/sec. These flows produced a near overtopping of the guide levees of the lower floodway and of the floodwall at Morgan City and, thus, made obvious a deficiency at that time of at least 600,000 ft^3/sec, or 40 percent. Lack of conveyance capacity in the lower floodway prevented the use of the West Atchafalaya Floodway and the use to full capacity of the Morganza Floodway. The leveed portion of the Atchafalaya River main channel accommodated 15 percent more than the design flow.

The present deficiency in floodway capacity relates to two major project parameters. These are the grade of the protection levees and the elevation of the project flow line. Notwithstanding continued improvements, the protection levees of the Atchafalaya Basin Floodway have remained deficient in both grade and section. This is partly because of poor foundation conditions and resulting subsidence and partly because of a continuous upward movement in the project flow line below river mile 55, or approximately Interstate Highway 10.

The project flow line is the flow line that would be produced during passage of 1,500,000 ft^3/sec through the floodway complex. The upward movement of this flow line is being caused by two major processes. The first is sedimentation in the backwater areas of the Atchafalaya Basin resulting in reduced cross-sectional area for overbank flow and storage. The second is development of a major delta in Atchafalaya Bay, which results in the seaward extension of the floodway (by the conversion of Atchafalaya Bay from an open water body to a complex of channels and overbank areas).

PRESENT AND FUTURE CONDITIONS IN THE MAIN CHANNEL

In a natural system, a river channel is not a static shape but is constantly changing size, cross-sectional shape, and alignment. In the alluvium of a coastal zone, these processes are more obvious. A river enlarges its bed by scouring when the water velocity is high and fills in its bed with sediment deposition when water velocity is low. It builds natural levees when overbank flooding takes place. This process leaves sediment on the banks of the river channel and permits the flood plain to receive water that does not bring with it enormous amounts of sediment. These natural levees, in turn, affect the channel, tending to increasingly confine the river between the banks of the natural levee before overbank flooding takes place. This changes every part of the river through time in a seaward direction. The river and its channel also change through time as the entrained sediment continuously builds a delta. This changes the gradient of the channel and the slope of the water surface. There are daily changes. The discharge will be higher during some parts of the year than others, and a larger part of the flood plain must be used to carry the water.

Furthermore, the plant and animal communities in the water and in the flood plain are delicately tuned to all of this fluctuation. Any change in course, any change in seasonal variation or overbank flooding, or any change in sediment deposition must cause an equal adjustment in the ecological balance of the entire flood plain.

No matter how complicated a system has developed, however, flood control is an essential use of the Atchafalaya Basin. Channel conditions in the Basin must meet flood control needs and provide for long-term use of the flood plain for that purpose. Unfortunately, this is not a simple requirement, even if ecological considerations are ignored. The hydraulics of maintaining a channel of sufficient size, and of obtaining a channel that will remain at a sufficient size, must include a calculation of all the factors that make the river and its channel a constantly fluctuating system.

Relationships among hydraulic elements in the Atchafalaya Basin Floodway system are summarized in Figure 10. The most important elements are the annual discharge regime as governed by the Old River Control Project, the distance between the Old River Control Project and the Gulf of Mexico, which is identified as the river length, and the division of flow between Wax Lake outlet and the Lower Atchafalaya River. With the ability of the river to modify its channel through scour and deposition, discharge regime and river length will ultimately determine the river slope and channel form of the future stable channel in which width, depth, and slope are related to discharge in such a manner that velocity is just sufficient to transport the sediment load.

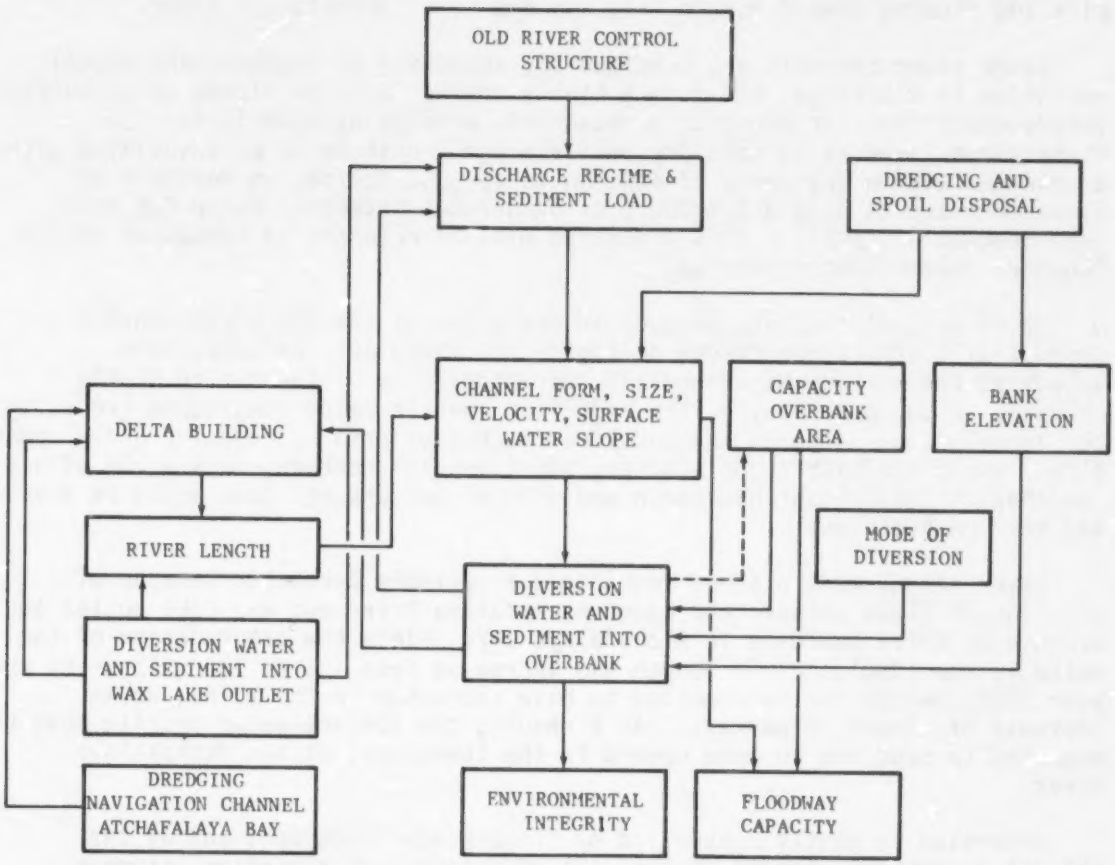


Figure 10. Relationships among hydraulic elements in the Atchafalaya Basin Floodway system.

Along the stream course, a number of other variables affect development and ultimate size, form, and surface-water slope of the channel. The most important among these is the diversion of water from the stream into the backwater area. The magnitude of discharge diversion along the Atchafalaya Basin main channel is illustrated in Figure 11. Below river mile 55 (Figure 12), diversion reduces main channel discharges from 10 percent to 25 percent at flows of approximately 425,000 ft^3/sec depending on return flows. The largest reduction follows with diversion of 30 percent of the initial discharge into Wax Lake outlet so that only 60 percent remains after about mile 100 flowing toward Morgan City and the Lower Atchafalaya River.

Since river channels are continuously adjusting to seasonal and annual variation in discharge, the future stable channel must be viewed as an average future condition. At present, a reasonable working hypothesis for the Atchafalaya River is to consider this average condition to be associated with discharges within the range of 400,000 to 450,000 ft^3/sec as measured at Simmesport and to have a frequency of occurrence between 1.5 and 2.5 years (van Beek et al. 1977). This discharge will be referred to hereafter as the "channel determinant discharge."

It is evident that any changes in operation of the Old River Control Project will affect the discharge regime and therefore the size, form, velocity, and surface-water profile characteristics of the future stable channel. More specifically, the reduction that is being considered (reducing the annual flood stage in the Red River backwater area by reducing annual peak flows) would diminish the discharges for given frequencies; this would affect the channel determinant discharge and size of the channel that would be stable and self-maintaining.

River length must also be considered a variable parameter because of division of flows between the Lower Atchafalaya River and Wax Lake outlet and because of delta building in Atchafalaya Bay. Since the progradation of the delta in the 1950's, river length has increased from 135 to 145 miles. By the year 2020, length can be expected to have increased to 160 miles, or an increase of almost 20 percent. As a result, the surface-water profile must be expected to continue to move upward in the lower part of the Atchafalaya River.

Diversion is mostly controlled by flood-plain topography and by the natural or manmade changes (Figure 10) affecting bank elevation, storage capacity of the overbank area, and the mode of diversion -- that is, whether diversion occurs through overflowing of the streambanks or through diversion channels.

Where diversion of water in the flood plain is prevented by artificial levees such as along the upper part of the Atchafalaya River, discharges of a given frequency are larger, and consequently the future stable channel will be larger, than along the lower reaches.

When diversion of water and sediment occurs from the channel into the flood plain mainly by overflow of the channel banks, most sediment is deposited on the streambank as natural levee ridges (Figure 13A). The

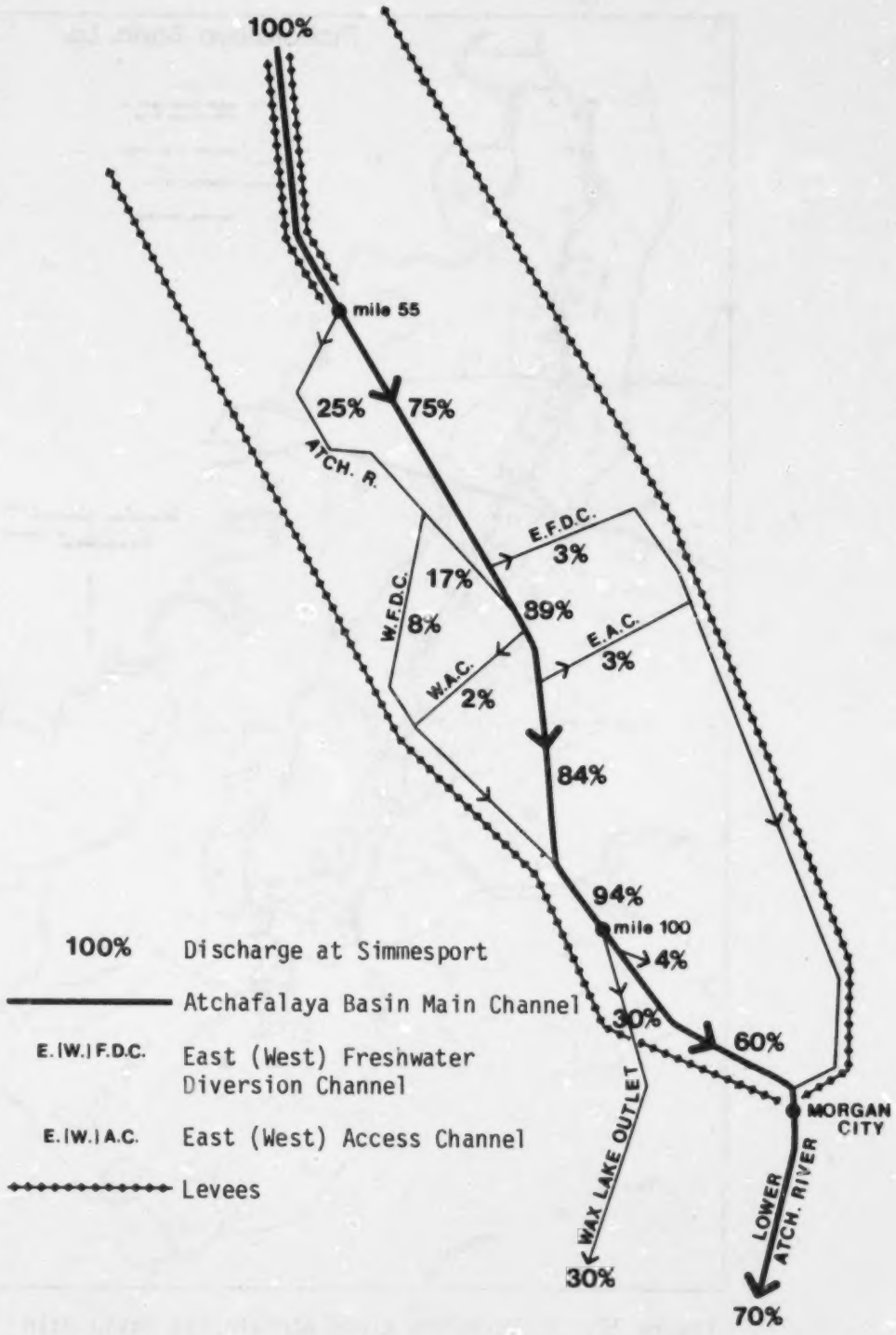


Figure 11. Diversion from the Atchafalaya Basin main channel during average annual flood.

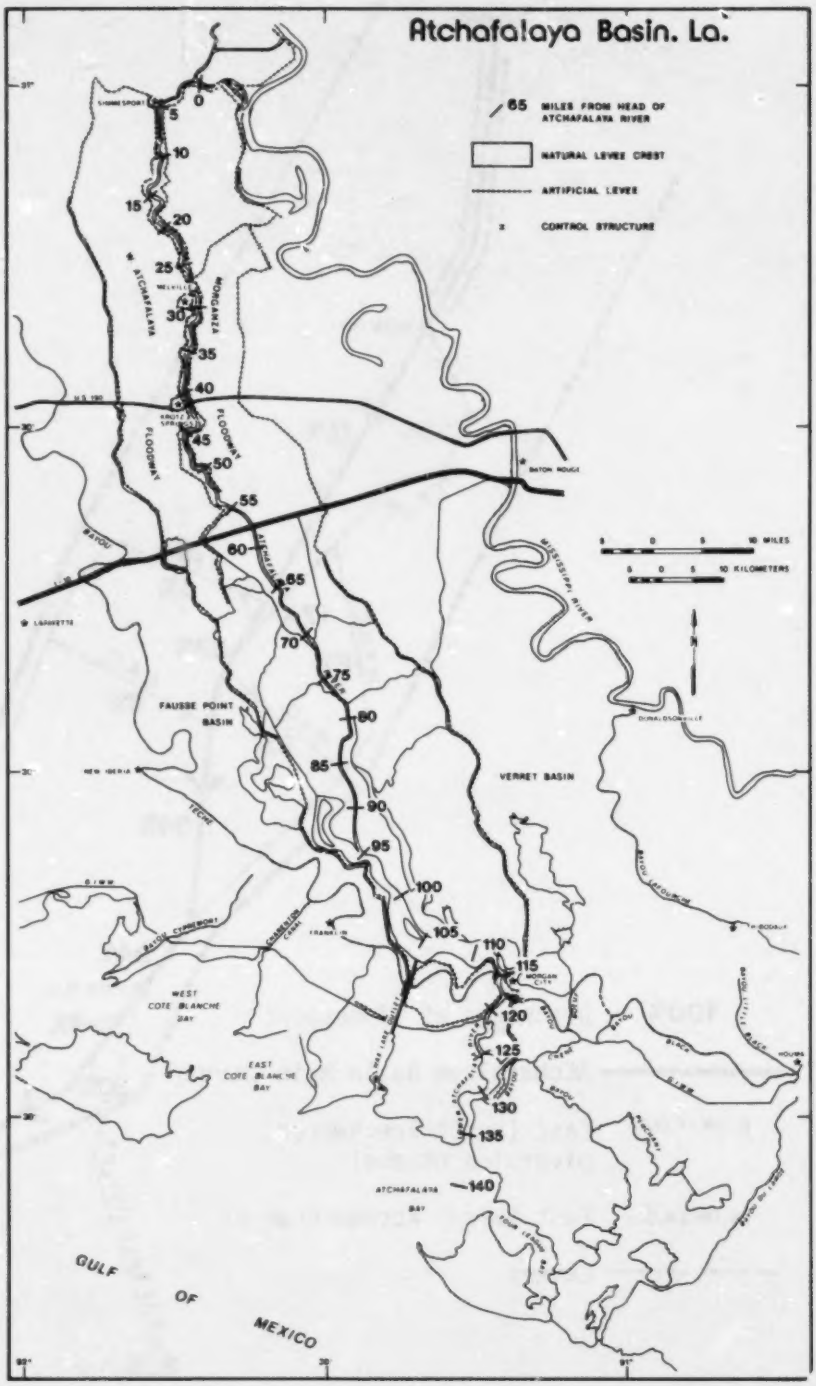


Figure 12. River miles along Atchafalaya Basin main channel.

resultant increase in bank elevation confines larger discharges for a given frequency thus allowing the river to maintain a larger channel. The process of enlargement will continue until the grade of the natural levee ridges follows the surface-water profile for the discharge of the channel determinant frequency. This type of adjustment reduces adverse deposition of sediments in the backwater area to only flood occurrences greater than the determinant discharge.

When most of the diversion of water into the flood plain takes place through diversion channels, however, a quite different condition develops (Figure 13B), in particular where banks have been elevated by spoil until overflow no longer occurs on a regular basis. Under those circumstances, diversion of water takes place at high velocity into the flood plain, enabling the water to carry large quantities of sediment. Most of the sediment is deposited in the backwater area, gradually reducing overbank capacity. Any resultant increase in channel discharges as a result of loss in overbank capacity will perpetuate the process of backwater sedimentation as long as the greater channel discharges or overall adjustment of the river gradient elevate the surface-water profile and thereby maintain the gradient into the backwater area. Channel enlargement will take place at much less than the potential rate since the increase in elevation of the surface-water profile minimizes the losses of overbank storage relative to the river so that channel discharges increase only slowly. Loss of overbank storage relative to a fixed datum plain, however, is considerable and represents a major loss of floodway capacity.

Enlargement of the Atchafalaya Basin main channel through dredging must be viewed also in terms of the above-discussed hydraulic relationships. Dredging will change the form, size, velocity, and surface-water slope characteristics of the main channel, as shown in Figure 10. This in turn will affect the diversion of water and sediments into the overbank area and therewith the discharge regime of the main channel. Whether the acquired channel will be stable depends on whether the new channel characteristics are in equilibrium with the then-occurring discharge regime, including the sediment load. Any major deviation from the required velocity and gradient for the channel determinant discharge and sediment loads will otherwise result in deposition within the channel. This would negate the channel enlargement accomplished by dredging, while any adverse impacts resulting from spoil disposal and from the decrease in annual duration and extent of flooding of the wetlands would remain.

The second effect of channel dredging stems from the associated spoil disposal if no measures are taken to control inflow through diversion channels. The spoil deposition would add to the relative change in bank elevation resulting from a lowering of the surface-water profile. This is true, in particular, since dredging would take place along the lower course of the main channel where overbank flow at present is still significant. The elimination of the overbank flow process during average annual floods would change the mode of water diversion into the overbank area to channel flow at higher velocities. This would adversely affect the desired reduction of sediment diversion into the overbank area obtained through lowering of the flow line.

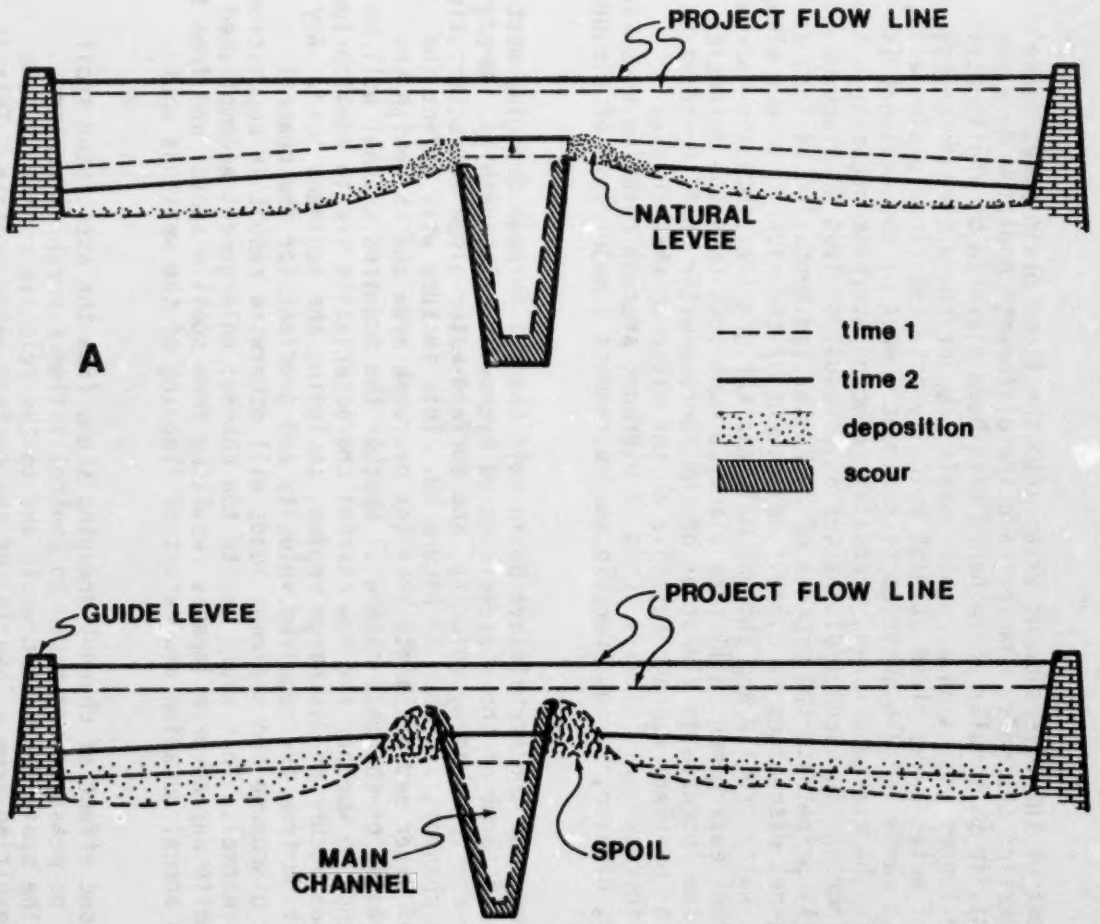


Figure 13. Annual flooding of backwater area and associated topographic and water-level changes. (A) Overflow across streambanks. (B) Overflow through channelized diversion.

Along the lower course of the Atchafalaya River, the most important factor becomes the division of main channel flows beween Wax Lake outlet and the Lower Atchafalaya River and the processes influenced by this division as shown in Figure 11. First, the division controls the channel determinant discharge for the remainder of the main channel and the Lower Atchafalaya River. Because of gradient advantage (the Wax Lake outlet route is some 15 miles shorter), discharges through the Wax Lake outlet and, consequently channel size, have increased since construction. Conversely, the channel determinant discharge along the Lower Atchafalaya River route continues to decrease.

Present processes of deltaic growth reinforce this trend. With 70 percent of total discharge still passing through the Lower Atchafalaya River, delta progradation is much more rapid on the east side of the Atchafalaya Bay causing a more rapid increase in length of the Lower Atchafalaya River than of Wax Lake outlet. That process is further augmented by maintenance of a navigation channel through the Atchafalaya River Delta.

With the above-described process-relationships in mind, we may now focus on present conditions and trends of the Atchafalaya Basin main channel. At present, neither the flow line nor the cross-sectional area of the Atchafalaya Basin main channel is stable. Figure 14 illustrates the trend flow-line change for a discharge of 450,000 ft^3/sec at Simmesport. Since 1969 the flow line has decreased in elevation upstream from the Whiskey Bay Pilot Channel (WBPC) while below the Whiskey Bay Pilot Channel the flow line has increased in elevation.

Also shown in Figure 14 are the project flow lines as determined in 1963 and in 1973 during the floodflows. The difference comprises a 4 ft upward revision as a result of sedimentation in the overbank areas and delta development. Since 1973, as a result of the flood and associated sedimentation, the flow line is being revised upward again, but the new flow line has not been made available yet.

The change in flow line for the 450,000 ft^3/sec discharge has been associated with a change in cross-sectional area of the channel. This trend is best illustrated by the bank-full datum plane (Figure 14), which at one time followed natural streambank elevation. The present flow line for 450,000 ft^3/sec is seen to lie well below this datum plane above mile 70 and far above this plane below mile 70. The change has been associated with strong scouring of the channel above mile 70 and with channel, levee, and flood-plain development below mile 70. These two processes are schematically shown in Figure 15A and Figure 15B, respectively.

Figure 15A shows the scouring of the channel and the associated lowering of the water level for a given discharge. Since water levels in the channel become lower relative to the overbank area, less water will be diverted and stages in the overbank area will decrease, resulting in a loss of aquatic habitat and reduction of the area periodically flooded. Below mile 55 such loss is further augmented because sediment introduction into the overbank area occurs increasingly through diversion channels rather than through overbank flow, and therefore most sediment is deposited in the aquatic habitats rather than on the channel bank. The process illustrated in Figure 15A will continue

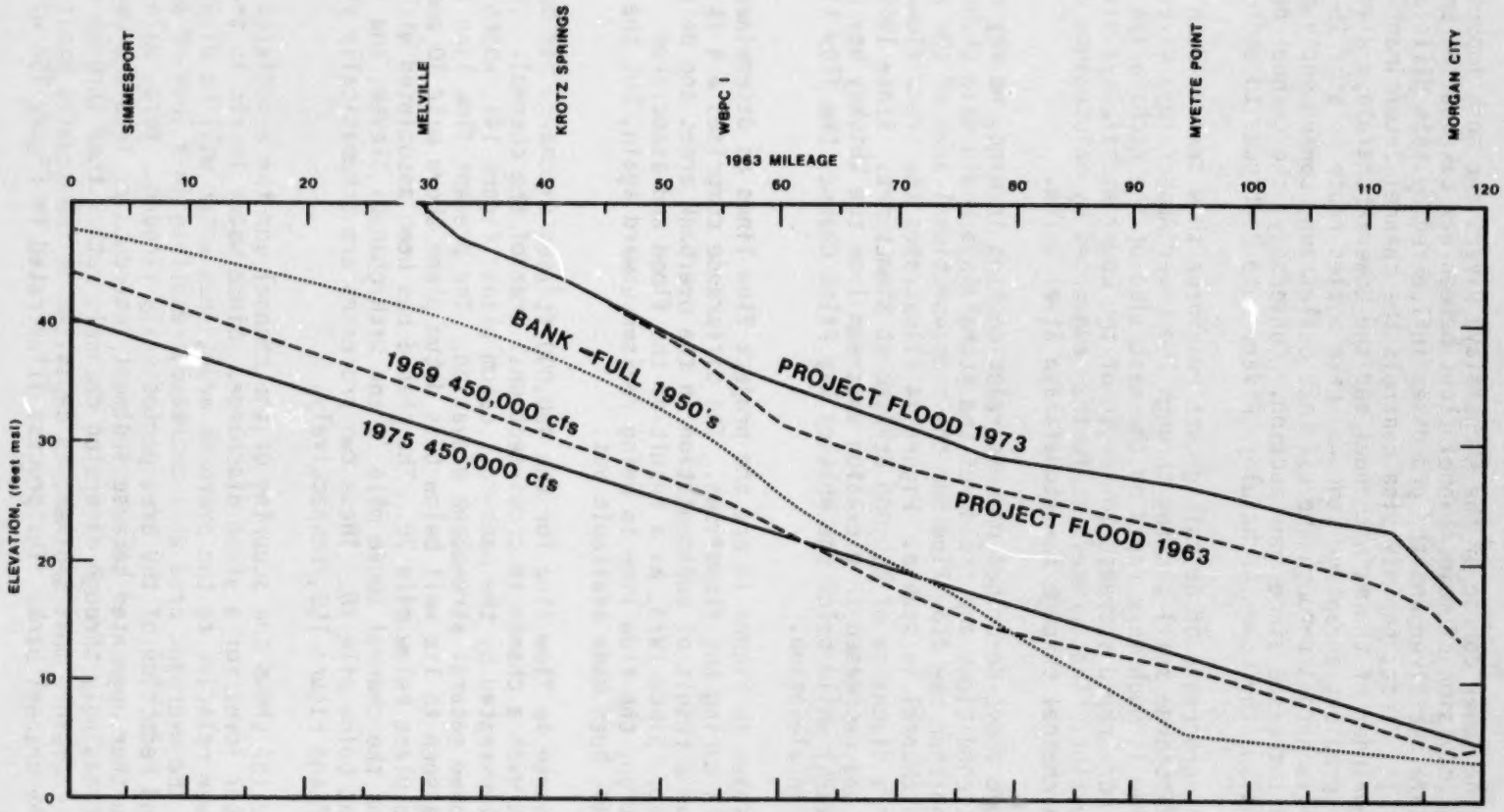


Figure 14. Changes in flow line along the Atchafalaya Basin main channel for the 450,000 ft^3/sec and project flood discharges. (The 1950's bank-full datum plane provides an additional reference).

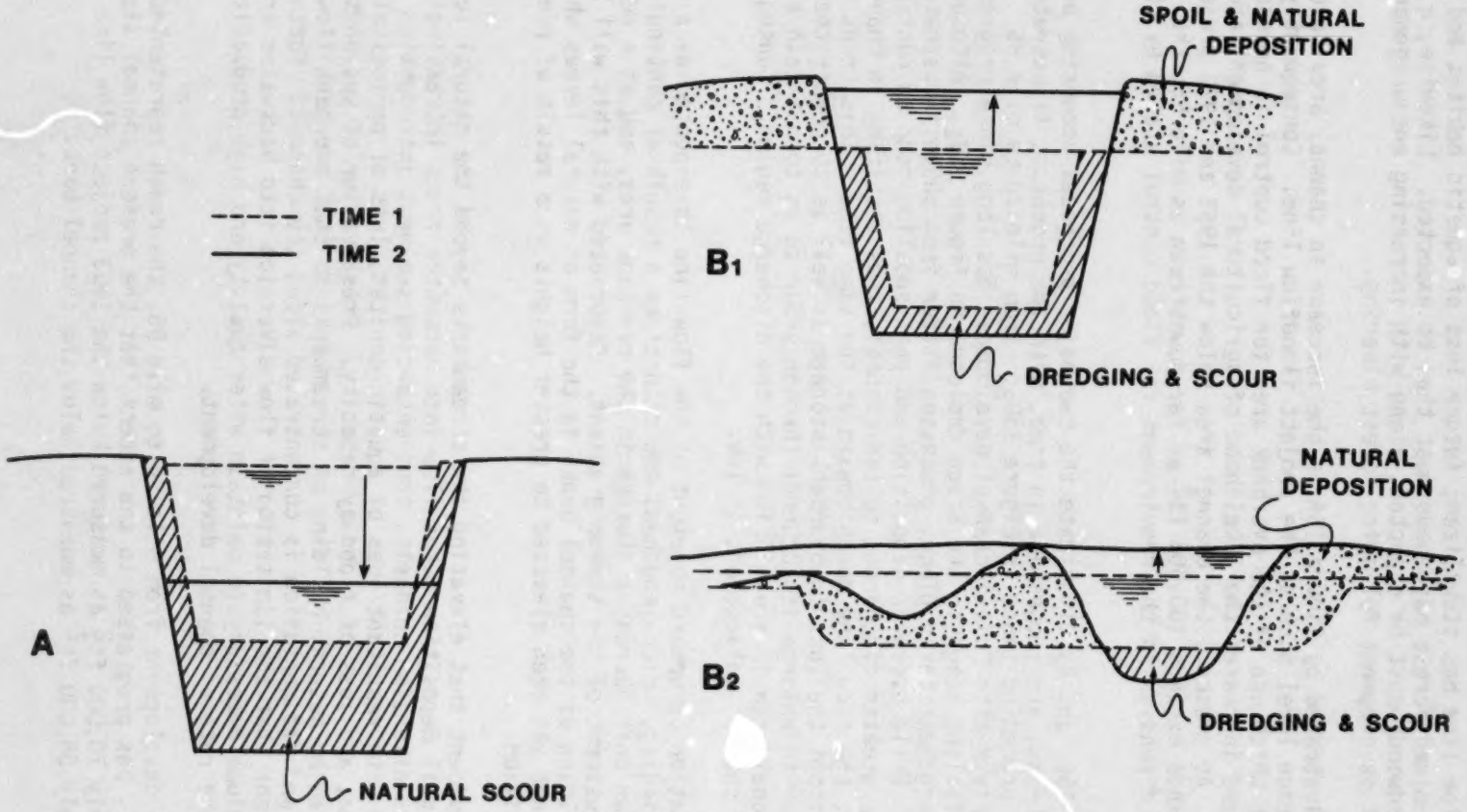


Figure 15. Schematic representation of channel and flow line changes along the Atchafalaya Basin main channel. (A) Channel scouring and associated lowering of flow line (above mile 70). (B_1) Scouring of channel and rise in flow line (mile 70-85). (B_2) Flow confinement through deposition, scouring of channel, and rise in flow line (mile 95-115).

until the flow line has stabilized; future loss of aquatic habitat and wetlands to mixed forest hardwoods must thus be expected. Likewise, a shift to drier hardwoods must be expected, along with increasing encouragement for agricultural development following forest clearing.

Also illustrated by Figure 15A is the increase in channel area below a fixed reference level such as the project floodflow line. Consequently, the frequency at which use of the overbank area for flood control is necessitated diminishes and increases the likelihood of agricultural development and settlement. At present, the channel area below the 1963 and 1973 project floodflow lines exceeds 100,000 ft^2 as far downstream as mile 55; the 100,000 ft^2 dimension is the requirement for flood control stated by the USCE.

Figures $15B_1$ and B_2 illustrate the two major processes occurring below mile 70. The two are successive in time, with the processes illustrated in Figure $15B_1$ preceding those in Figure $15B_2$. From mile 70 to mile 95 (approximately Myette Point) channel development has long since progressed beyond the filling stage to the stage depicted in Figure $15B_1$. Although channel enlargement takes place, processes differ from those illustrated in Figure 15A. While overbank deposition and past spoiling tend to confine increasingly greater discharges to the channel, thus resulting in channel enlargement, the flow line moves upward at the same time. This tends to partially offset the loss in overbank storage as well as to negate the need for the river to enlarge its channel through scour so as to maintain a cross-sectional area in equilibrium with the discharge regime. Consequently, the rate of channel enlargement is low.

Continuation of upward movement of the flow line is expected as a result of delta building, which lengthens the channel as a result of continuing sedimentation that decreases storage in the overbank area, and as a result of overall adjustment of the stream gradient. Associated with this will be natural building of the channel banks in the form of natural levees where banks have not yet been elevated to greater heights as a result of previous spoil deposition.

It is evident that elevating the streambanks beyond the natural levee height by spoil deposition makes flow into backwater areas increasingly dependent on diversion channels, thus enhancing sediment introduction into these areas with resultant loss of aquatic habitat, loss of periodically flooded area, and loss of floodway capacity. Preservation of wetlands is much better served by natural building of streambanks so that overbank flow is maintained and sedimentation is concentrated along the channel. Furthermore, it is apparent that the limitation of flow diversion into backwater areas to only the volume necessary to maintain water quality and high productivity increases the rate of channel development.

Channel development from mile 70 to mile 95, the reach represented by Figure $15B_1$, has progressed to the extent that the present channel size is approximately 70,000 ft^2 as measured below the 1963 project flow line and approximately 58,000 ft^2 as measured below the channel bank.

Between the time dredging was stopped, in 1968, and early 1973, the channel increased in size from mile 70 to mile 83 and remained stable from mile 83 to mile 95. However, the 1973 flood produced a reduction as a result of sedimentation throughout the 25-mile reach. Table 2 summarizes the changes.

TABLE 2. RATES OF CHANNEL DEVELOPMENT ALONG THE ATCHAFALAYA BASIN MAIN CHANNEL

Period	Years	Main Channel Segment (mi)	Total Average Change (ft^2)	Average Annual Rate of Change (ft^2)
1969-1973	4	55 - 70	+5,746	+1,436
1973	1	55 - 70	+10,702	+10,702
1969-1973	4	70 - 83	+2,840	+710
1973	1	70 - 83	-4,603	-4,603
1969-1973	4	83 - 95	+48	+12
1973	1	83 - 95	-3,343	-3,343
1971-1973	2	95 - 103	+2,097	+1,048
1971-1973	2	103 - 112	+348	+174
1972-1973	1	112 - 120	-17	-17
1973	1	95 - 112	-967	-967
1973	1	112 - 120	+19,191	+19,191

Below Myette Point (mile 95) where the main channel follows Six Mile Lake, the flow conditions are rapidly changing as a result of the processes shown in Figure $15B_2$. Through deposition in the lake on either side of the main current thread, the channel increasingly gains definition and the flows become more confined. This contributes further to the rise in flow line. With additional confinement of flows and an increase in velocities, the river will increase its depth by scour insofar as sufficient depth is not provided by the rise in flow line.

The situation just described is complicated, however, by the partial diversion of discharge to the Wax Lake outlet at approximately mile 103 and by the fact that the diversion ratio has been increasing because of gradient advantage. Related to this, the channel size from mile 95 to mile 103 averages 50,000 ft^2 below the 1963 flow line but decreases to about 30,000 ft^2 in the confined reach of the Lower Atchafalaya River. The rate of channel development follows the same trend, being much greater above the diversion point than below that point as shown in Table 2 (miles 95-103 and 103-112). Deposition and decrease in channel size associated with the 1973 flood were about equal in both reaches.

At this point it must be emphasized again that a distinction has to be made between active channel cross section and channel cross section as expressed by the USCE. The active channel cross section is the cross-sectional area of the channel occupied by the river during flood discharges that are representative for the river's regime. The cross-sectional area as expressed by the USCE is the area below a fixed datum plane in which channel-flow conditions occur when water level in the river equals the level of the datum plane. This can be extremely misleading to those not familiar with the USCE meaning of channel cross section when changes in cross-sectional area of the channel are considered. True changes can only be observed by considering both the change in surface-water profile and cross-sectional area below a fixed datum plane. This is illustrated by Table 3.

Simultaneous consideration of riverine processes and the trends of the surface-water profile and channel cross section below a fixed datum plane indicate the following. Through a complex system of interacting processes (Figure 10) involving the river channel, overbank area, and delta, the Atchafalaya River attempts to achieve stability for the present discharge regime. This stability requires a change in surface-water slope, active channel cross section, and velocity. Above approximately mile 70 the change involves a downward adjustment of the surface-water profile associated with channel enlargement through scour (Condition 7, Table 3). Because the rate of scour greatly exceeds the rate of profile adjustment, the active channel is enlarging through scour.

Below mile 70 the gradient adjustment results in an upward movement of the surface-water profile that is associated with a decreasing rate of scour from mile 70 to mile 95 (Condition 1, Table 3) and with essentially no change from mile 95 to Morgan City (Condition 2, Table 3) except between mile 95 and 103. Scouring between mile 95 and 103 is, however, a superimposed condition related to rapid scouring in the branch channel leading to Wax Lake outlet, which scoured at an average annual rate of 2,000 ft^2. Active channel cross

TABLE 3. POSSIBLE NET CHANGE IN CHANNEL CROSS SECTION FROM COMBINED CHANGES IN THE BED AND FLOW LINE

Condition	Surface-Water Profile		Channel Cross-sectional Area Below Fixed Datum		Net Change in Cross Section for Discharge Representative of Discharge Regime ($\Delta A_1 + \Delta A_2$)
	Direction of Change	Change In Cross. Area (ΔA_1)	Process of Change	Change In Cross. Area (ΔA_2)	
1	up	$\Delta A_1 > 0$	scour	$\Delta A_2 > 0$	$\Delta A_1 + \Delta A_2 > 0$
2	up	$\Delta A_1 > 0$	same	$\Delta A_2 = 0$	$\Delta A_1 + \Delta A_2 > 0$
3	up	$\Delta A_1 > 0$	deposition	$\Delta A_2 < 0$	$\Delta A_1 + \Delta A_2 >$, =, or < 0
4	same	$\Delta A_1 = 0$	scour	$\Delta A_2 < 0$	$\Delta A_1 + \Delta A_2 > 0$
5	same	$\Delta A_1 = 0$	same	$\Delta A_2 = 0$	$\Delta A_1 + \Delta A_2 = 0$
6	same	$\Delta A_1 = 0$	deposition	$\Delta A_2 < 0$	$\Delta A_1 + \Delta A_2 < 0$
7	down	$\Delta A_1 < 0$	scour	$\Delta A_2 > 0$	$\Delta A_1 + \Delta A_2 >$, =, or < 0
8	down	$\Delta A_1 < 0$	same	$\Delta A_2 = 0$	$\Delta A_1 + \Delta A_2 < 0$
9	down	$\Delta A_1 < 0$	deposition	$\Delta A_2 < 0$	$\Delta A_1 + \Delta A_2 < 0$

sections are thus enlarging along both of the above reaches at greater rates than indicated by physical channel changes because of surface-water profile adjustments. From mile 70 to 95 active channel enlargement amounts to approximately 1,200 ft^2 per year, which includes 700 ft^2 as a result of scour and 500 ft^2 as a result of increased water levels for the representative discharge. Below mile 95 the active channel enlargement represents primarily an increase in water levels and an associated increase in elevation of the banks through deposition and amounts to about 250 ft^2 per year. The absence of scour suggests that, presently, changes in the discharge-channel relationships are still accommodated by changes in slope and depths without necessitating scouring to satisfy hydraulic requirements. In other words, the channel appears stable for the given conditions of slope, water depth, and velocity. This is further indicated by a decrease in cross-sectional area as the result of deposition following the termination of channel enlargement by dredging in 1963.

As can be seen from this discussion, the potential rate of channel enlargement through scour for average discharge conditions is on the order of at least 1,500 ft^2 per year when adjustment of surface slope insufficiently increases or diminishes water depth and forces a greater water depth through scour. This means that channel dimensions below the 1963 datum plane that are considered for flood control could be attained according to the time frame given in Table 4 if the projected channels would be in accord with the stable conditions the river attempts to establish under present regime conditions.

TABLE 4. ESTIMATED TIME REQUIREMENTS FOR NATURAL CHANNEL ENLARGEMENT TO ALTERNATIVE DIMENSIONS OF 100,000 ft^2 AND 80,000 ft^2

Channel Area below 1963 Datum Plan ft^2	Main Channel Segment River Miles	Estimate of Years Required this Report (base year 1973)	Estimate of Years Required USCE* (base year 1973)
100,000	0 - 55	0	0
80,000	0 - 55	0	0
100,000	55 - 95	20	32
80,000	55 - 95	7	3
100,000	95 - 105	33	60+
80,000	95 - 105	20	21
80,000	95 - 112	35	42

*New Orleans District, U.S. Army Corps of Engineers, letter of March 29, 1978, to Victor W. Lambou, Project Officer for this study, from Early J. Rush III, District Engineer.

AGRICULTURAL USE AND SETTLEMENT

The combined Red River backwater area and Atchafalaya Basin Floodway complex were meant to provide protection from floodwater for urban, industrial, and agricultural development along the Lower Mississippi River. However, their structural and nonstructural provisions have also encouraged expanded agricultural development and settlement within the Atchafalaya Basin areas designated to receive floodwaters and in the areas adjacent to the floodway that must serve as storage for local storm runoff during operation of the floodway system. That development has invariably expanded into bottom-land hardwoods and forested wetlands and generated demands for small watershed drainage projects to be undertaken by the USDA Soil Conservation Service as well as demands for reduced diversion of Mississippi River water through the Old River Control Project.

In this section, the settlement and agricultural uses that have developed will be treated separately for the Red River backwater area, the West Atchafalaya Floodway, the Morganza Floodway, and the Atchafalaya Basin Floodway. Then, an analysis will follow of the general effects of agricultural development (and, specifically, its inescapable byproduct, agricultural runoff) on floodway capacity and on aquatic habitats.

RED RIVER BACKWATER AREA

The Red River backwater area comprises approximately 1,360,000 acres, nearly all of which is privately owned. Despite its designated role as a floodwater storage area and the frequent overflow of much of the area, the Red River backwater area is undergoing increased residential and agricultural development. This development expands from the low alluvial ridges into the even lower flood-plain areas following the clearing of bottom-land hardwoods and in some cases construction of local flood-protection levees. In 1959, about one-third of the area (or 450,000 acres) had been cleared (U.S. Army Corps of Engineers 1968). In 1976, approximately 655,500 acres were in use as croplands or pastures (FWS, unpublished data).

This entire area drains, through the Red River, into the upper Atchafalaya River above Simmesport. The stages in the Red River will be higher, because of backwater flooding, if the stages in the upper Atchafalaya River are high. Since the stages of the Atchafalaya River are a result of the volume of water diverted from the Mississippi River by the Old River Control Project, the stages of the Red River backwater area are directly dependent upon operation of the Old River Control Project.

Even though, geographically, the Red River backwater area is not in the Atchafalaya Basin, it must be considered here because of its dependence on the diversion by the Old River Control Project. Increasing development into the flood-plain areas of the Red River backwater area will generate mounting political pressure to decrease the volume of diversion by the Old River Control Project. The ecological system of the Atchafalaya Basin as well as its value as a floodway is integrally related to the volume of diversion by the Old River Control Project.

The extent to which agricultural development has moved into marginally suited areas is illustrated by the 1974 conditions within the 365,000 acres of the Red River backwater area that fall within the New Orleans district of the USCE (U.S. Army Corps of Engineers 1975). The 1974 flood conditions, which occur with a frequency of one in five years, resulted in the flooding of 55,000 acres of agricultural land and 500 acres of rural residentially developed land. Floodwaters reached depths of 6 to 8 ft over some agricultural lands. As a result, damage amounted to more than $2,000,000 in lost crops alone.

Under present conditions, no control can be exerted over further development and the associated clearing of bottom-land hardwoods. Except for 11,000 acres within the ring levee system of Bayou des Glaises Loop immediately north of the West Atchafalaya Floodway, even simple flowage easements have not been obtained.

WEST ATCHAFALAYA FLOODWAY

This floodway contains approximately 760,000 acres, which are practically all in private ownership. The area is seperated from the Red River backwater area by the fuse plug levee, and a main levee prevents annual overflow from the Atchafalaya River main channel. Annual water-level fluctuations are therefore controlled by local runoff and by backwater flooding from the Old Atchafalaya River into which part of the Atchafalaya River flow is directed from the main channel at river mile 55. This condition has afforded considerable protection from Atchafalaya River flood stages. Protection from flooding combined with restriction to land use of only simple flowage easements has resulted in expanding agricultural development in the West Atchafalaya Floodway and the clearing of bottom-land hardwoods (U.S. Army Corps of Engineers 1975). Recent mapping (1977) of land resources by the USCE and FWS show that more then one-third of the area, or about 58,500 acres, is presently used for croplands and pastures. The USDA Soil Conservation Service has received an application for planning of a small watershed project involving 165,000 acres (U.S. Department of Agriculture 1976). The expansionary trend of development and settlement is further illustrated by the biannual USCE census data. This trend is shown in Table 5. Despite the 1973 flood and the continued above-normal stages during 1974, the rate of population increase from 1974 to 1976 was nearly double that of 1970 to 1974.

TABLE 5. SETTLEMENT IN THE WEST ATCHAFALAYA FLOODWAY*

Year	Structures	Persons	Growth Rate	Livestock
1970	1,147	3,426		11,501
1974	1,217	3,509	20.75/yr	10,000
1976	1,322	3,581	36.00/yr	10,832

*USCE, unpublished data.

Under present conditions, agricultural use of the West Atchafalaya Floodway is further stimulated. The present capacity deficiency of the Atchafalaya Basin Floodway prevents the use of the West Atchafalaya Floodway for diversion of floodwaters from the Red River backwater area across the fuse plug levee. Furthermore, the Atchafalaya River main channel within the levee reach exceeds considerably the design capacity of 600,000 ft^3/sec.

In 1973, the channel accommodated 781,000 ft^3/sec, and the stage-discharge rating curve for Simmesport indicates that present channel capacity below the project flow line is at least 950,000 ft^3/sec -- that is, 270,000 ft^3/sec in excess of the magnitude required for passage of the project flood. This reduces greatly the frequency of events necessitating use of the West Atchafalaya Floodway and thus encourages development of and settlement in the floodway.

MORGANZA FLOODWAY

In the Morganza Floodway nearly all lands are also privately owned. However, a greater degree of control can be and has been exerted over land use through acquisition of comprehensive flowage easements. In addition to the right of overflow, the easements provide for control over settlement, grazing, and land clearing insofar as these are related to maintenance and operation of the area as a floodway. As a result, no building of permanent structures has been allowed. However, the biannual census showed a total of 97 structures and 21 persons residing in the floodway in 1976 (Table 6). This settlement has been possible by allowing settlement in house trailers.

TABLE 6. SETTLEMENT OF THE MORGANZA FLOODWAY*

Year	Structures	Population	Livestock
1970	33	0	3,242
1976	97	21	3,110

*USCE, unpublished data.

The easements have not been administered to prohibit land clearing, since removal of timber was not considered to have a direct, adverse effect on the floodway operation. As a result, approximately 18,000 of the 64,000 acres contained in the Morganza Floodway are presently in use as croplands and pastures.

ATCHAFALAYA BASIN FLOODWAY

At present very little control can be exerted over land use in the Atchafalaya Basin Floodway. This is illustrated in Table 7. The table shows that, of the 600,000 acres contained in the Atchafalaya Basin Floodway, only 132,000 acres, most of it water bodies, are subject to direct control under State ownership. Included is the Atakapas Outdoor Recreation Area, which is presently administered by the Louisiana Department of Culture, Recreation, and Tourism but is expected to be transferred in 1978 to the Louisiana Wild Life and Fisheries Commission as a Wildlife Management Area.

Nearly 470,000 acres, or 80 percent, are privately owned with few or no restrictions on use. Present authorization allows the USCE to acquire simple flowage easements on a claim basis for those areas not subject to frequent overflow as of 1928. Although this applies to 68,000 acres, claims have been filed and simple flowage easements obtained on only 9,100 acres or less than 2 percent of the floodway area to date. In addition, the USCE has required servitudes for channel realignment and spoil disposal on 50,000 acres, which precluded permanent structures except hunting or fishing camps.

TABLE 7. OWNERSHIP AND SERVITUDES IN THE ATCHAFALAYA BASIN FLOODWAY*

Ownership	Acres	of Total	Servitudes	Comments
Private	350,000	58	none	
Private	9,000	2	simple flowage	
Private	58,000	10	none	Simple flowage easement can be claimed by owner
Private	50,000	8	Spoil disposal and channel servitude	No structures
State	25,000	4	-	Atakapas Recreation area
State	107,000	18	-	Water bottoms

*USCE, unpublished data.

The above data can be integrated with habitat information as developed under the USCE and FWS Habitat Evaluation Program. Spoil servitudes and State ownership apply mostly to open-water and willow-cottonwood-sycamore habitats. Present flowage easements are largely coincident with already cleared lands that are in cropland or pasture use. This leaves approximately 250,000 acres of bottom-land hardwoods and 135,000 acres of swamp forest that are privately owned and on which no direct control concerning use can be exerted.

Higher elevation and partial protection from annual overflow by Atchafalaya River levees have allowed for agricultural development mostly in the upper part of the Atchafalaya Floodway between U.S. Highway 190 and Interstate Highway 10. In this area, land cleared for agriculture has increased from approximately 5,800 acres in 1969 to 8,500 acres in 1974, and to 9,300 acres in 1977.

Table 8 shows a significant decrease in population following the 1973 and 1974 floods. Population only slightly increased after those years. The majority of permanent settlement is in the northwestern part of the Atchafalaya Basin Floodway along U.S. Highway 90.

Most permanent structures are hunting and fishing camps, but vacation house development is proceeding as a real estate venture near the community of Butte la Rose near I-10.

EFFECTS OF AGRICULTURAL DEVELOPMENT

It is difficult to evaluate the effects of agricultural development and specifically of the associated agricultural runoff on the aquatic habitats of the Atchafalaya Basin inside and outside the floodway. It is also hard to evaluate the effect of agricultural runoff on floodway capacity. A better evaluation of the effect on aquatic habitat may be possible following completion of the Atchafalaya Basin Water Quality Study by the EPA. However, the fact cannot be ignored that runoff from agricultural fields contains large quantities of eroded topsoil, fertilizer chemicals, and animal manure. Roughly 50 percent of fertilizers applied to crops ultimately reach natural waters (Gilliam and Terry 1973). In view of this, a number of observations should be made.

TABLE 8. SETTLEMENT IN THE ATCHAFALAYA BASIN FLOODWAY*

Year	Population	Structures	Livestock
1970	673	490	1154
1974	690	294	970
1976	888	308	735

*USCE, unpublished data.

Agricultural runoff from the fields in the Morganza Floodway, West Atchafalaya Floodway, and Atchafalaya Basin Floodway is discharged directly into the wetlands to the south, without the benefit of dilution by being first incorporated in the Atchafalaya River discharge. The same is true for agricultural runoff diverted through the Courtableau drainage structure into the Bayou Fordoche management unit from the Basin area to the west of the floodway. In all cases agricultural runoff is received by aquatic habitats that are subject to backwater flooding with inherent reduced circulation.

The above conditions must also be viewed against present water quality parameters other than low dissolved oxygen values. The flux of nutrients into the Atchafalaya Basin is high. Craig et al. (1977) estimated the mean annual flow of nutrients through the basin to be 30,000 metric tons/yr phosphorus and 264,000 metric tons/yr nitrogen. The mean nutrient concentrations in the Atchafalaya River at Simmesport are 1.53 mg/l of total nitrogen and 0.18 mg/l of total phosphorus (U.S. Geological Survey 1976). These values are even higher within the swamp basins. Mean concentrations in water of the Buffalo Cove and Upper Belle River management units were found to be 1.86 mg/l for total nitrogen and 0.21 mg/l for total phosphorus. Craig et al. (1977) state that these levels are high compared to areas in the Louisiana coastal zone that are considered eutrophic.

Agricultural runoff as a result of expanding development in the swamp basins adjacent to the floodway may even be more detrimental since these systems are entirely dependent on local rainfall for water supply. No data concerning nutrient influx into these basins are presently available. Neither is the projection of water quality conditions related to expansion of agricultural development as a result of USSCS watershed projects. A large number of such projects are in the planning stage or have been approved for implementation. Along the east side, in the Verret Subbasin, these include the Johnson Bayou, Bayou Grosse Tete, Choctaw Bayou, Bayou Plaquemine, and Lake Verret watersheds with a total of 729,793 acres. All plans except those for Bayou Plaquemine have been approved for operation.

Along the west side of the floodway, USSCS watershed projects affecting the Basin are the Upper Bayou Teche, Wauksha-Courtableau, Avoyelles-St. Landry, Chatlin Lake Channels, and Bayou Boeuff projects with a total of 894,490 acres. These projects affect quality of the waters and associated wetlands of the Fausse Point Subbasin as well as those of the floodway swamps. The swamps are affected because drainage for the four northernmost projects is to be provided by diversion of runoff into the floodway at the latitude of U.S. Highway 190.

Information on sediment content in runoff from farmlands peripheral to the Atchafalaya Basin is almost nonexistent. State and Federal agencies that were contacted (Louisiana State Planning Office, Soil Conservation Service, U.S. Geological Survey, Agriculture Research Service, and U.S. Army Corps of Engineers) all agreed that such information would be invaluable in any management pursuit. However, they all stated that acquiring this type of information for the Atchafalaya Basin and surrounding area would be very expensive and would require lengthy field investigation because of the

complexity of runoff and circulation in the area. The Lake Verret watershed project is the only attempt that has been made to quantify the sediment-runoff relationship for this area, and the data collected in that study were never verified.

Consequently, quantification of how much sediment enters the Atchafalaya Basin from either the surrounding or the internal agricultural lands still needs to be made through acquisition of realistic data. Some indication of the potential importance of the problem can be obtained from studies in other areas of similar topographical and climatological setting such as was performed in the delta area of Mississippi by the U.S. Department of Agriculture.

ALTERNATIVES FOR OPERATION OF THE OLD RIVER CONTROL PROJECT

Three alternatives for the future operation of the Old River Control Project will be evaluated. The first alternative is to maintain diversion as presently authorized. The second alternative is to limit diversion so that the stages in the Red River backwater area at Acme, Louisiana, are reduced during the spring planting season and the area currently inundated is reduced. Three different stage levels are analyzed under this "limit diversion" alternative -- the so-called 35-ft, the 40-ft, and the 45-ft plans, the numbers referring to the stage levels at Acme during spring planting. A third alternative is to manage diversion in order to meet the requirements of the aquatic ecosystems in the Atchafalaya Basin Floodway complex.

MAINTAIN PRESENT DIVERSION

The percentage of the latitude flow to be diverted at the Old River control structure to the Atchafalaya River was mandated by the 83rd Congress to be 30 percent. Allowing for a 7.5 percent operational margin either way, the operation of the Old River Control Project has been in general compliance with the mandated diversion of flows. This is illustrated in Figure 16, which gives the Atchafalaya River flows at Simmesport as a percentage of the latitude flow for the months of January, March, June, September, and December for the period of operation.

However, four significant deviations from mandated flow control can be noted. These include deficits in 1963, 1964, 1966, and 1976 and flow excesses in 1974 and 1975. The 1963 deficit is associated with the first months of structure operation following its opening on July 15. In 1964 as well as 1966, barge accidents in front of the structure necessitated partial closure of the gates for salvage operations and to prevent further damage.

Both deficits and excesses from 1974 through 1976 relate to the 1973 flood when the Old River control structures were severely undermined as a result of scour. To prevent further scour, stage differentials across the structures are no longer allowed to exceed 18 ft. This necessitates increased diversion during annual flood conditions. In 1976 partial closure of the structures was needed to make possible some necessary repairs in the stilling basin.

Diversion of Mississippi River flow results presently in an average annual peak flow of 430,000 ft^3/sec into the Atchafalaya River at Simmesport, Louisiana. The associated stage at this location is 40.7 MSL based on the 1976 discharge rating curve. The annual regime of the Atchafalaya River at

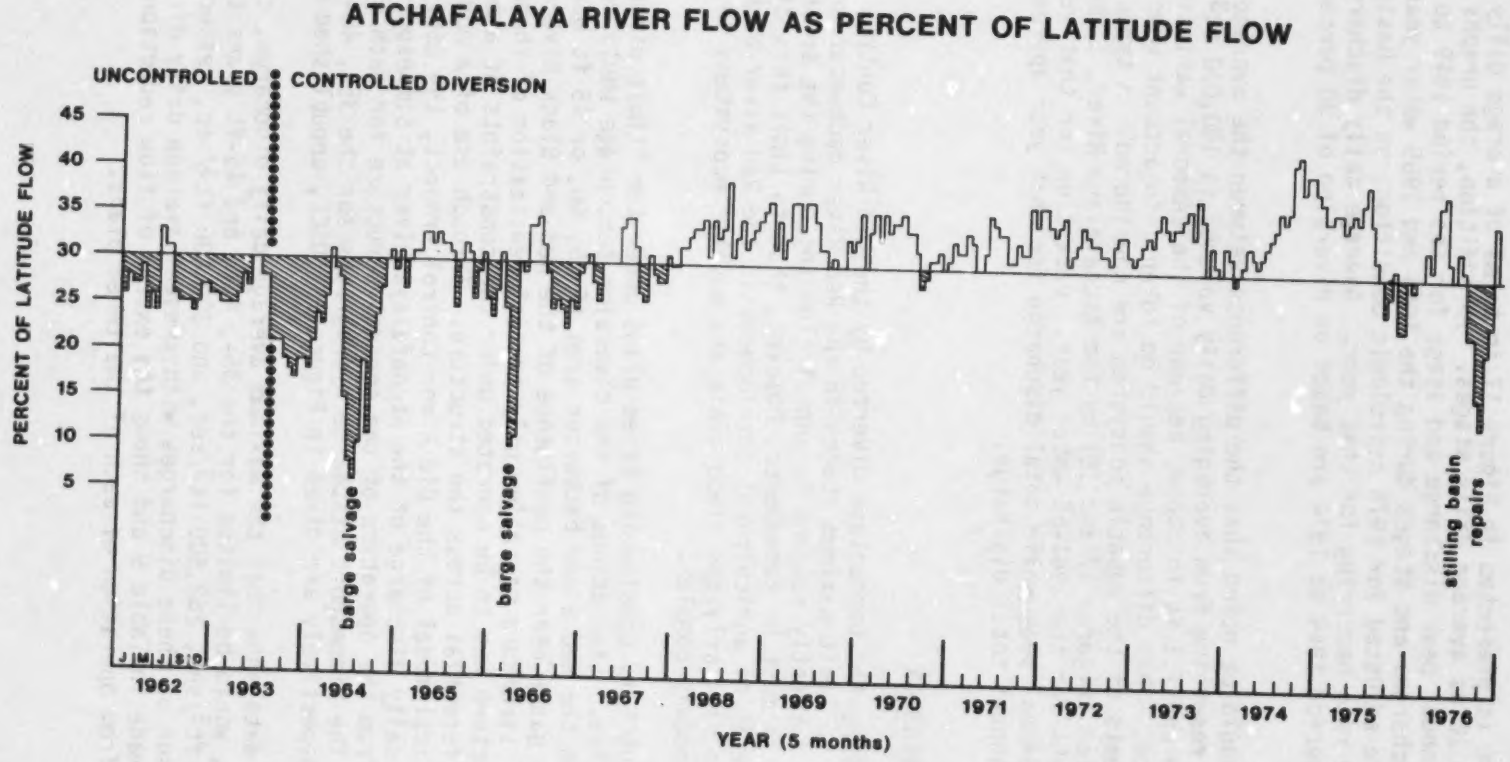


Figure 16. Atchafalaya River flow as a percentage of latitude flow (Mississippi River and Red River) at 3-month intervals from 1962 through 1976.

Simmesport is presented in Figure 17 in terms of average daily discharges and in Figure 18 as average daily stages. In addition, the graphs show the average annual peak discharge and stage for the period 1949 to 1974 and the daily discharges and stages during the 1964 and 1965 water year. The latter stages are adjusted for 1976 hydrologic conditions on the basis of the discharge rate occurring for that year. Average daily discharges and stages for the period 1949 to 1974 are based on diversion of 30 percent of latitude flow.

It should be noted that the difference between the average annual peak and the peak resulting from averaging daily volumes is 100,000 ft^3/sec in discharge and 7.1 ft in stage, because of the temporal variation in peak flow occurrence. This difference should be taken into account when annual flooding requirements of the aquatic ecosystem are considered. A typical difference is illustrated (Figures 17 and 18) by the Atchafalaya River, Simmesport, hydrographs for the 1964-65 water year. Peak flow for that year equaled the average annual peak while total discharge for that year approximated the average annual total discharge.

LIMIT DIVERSION

Limiting the percentage diverted by the Old River Control Project makes it possible to limit maximum stages in the Red River backwater areas and reduce the area currently subject to annual flooding during the spring planting season. It must be remembered, however, that to limit this diversion for the sole benefit of agricultural development in the Red River backwater area is to influence similarly the flood plain and aquatic ecosystems in the Atchafalaya Basin Floodway complex.

The USCE is considering three plans under the "limit diversion" alternative. Limitations of the diversion percentage would result in maximum stages in the Red River backwater area of 35, 40, or 45 ft MSL as measured at the Acme gauge near the confluence of the Red and Black Rivers. The present low sill structure may allow only partial realization of these alternatives if the structure has to be operated under the constraints of a maximum allowable head differential across the structure. Through use of a modified mathematical model of the Old River Control Project, the USCE estimated the average daily discharge of the Atchafalaya River at Simmesport that would result from the operation of the control structure for each of the above three plans. The Simmesport discharge hydrographs for the 35-, 40-, and 45-ft MSL plans respectively are given in Figure 19 (USCE, unpublished data).

The data show that the maximum average daily discharge, occurring after April 1, would be limited for the 35-, 40-, and 45-ft plans to approximately 250,000 ft^3/sec, 262,500 ft^3/sec, and 300,000 ft^3/sec, respectively. A comparison of these discharges with present average daily discharges (Figure 19) is made in Table 9 and shows the extent of flow reduction that would result from operation of each of the three plans.

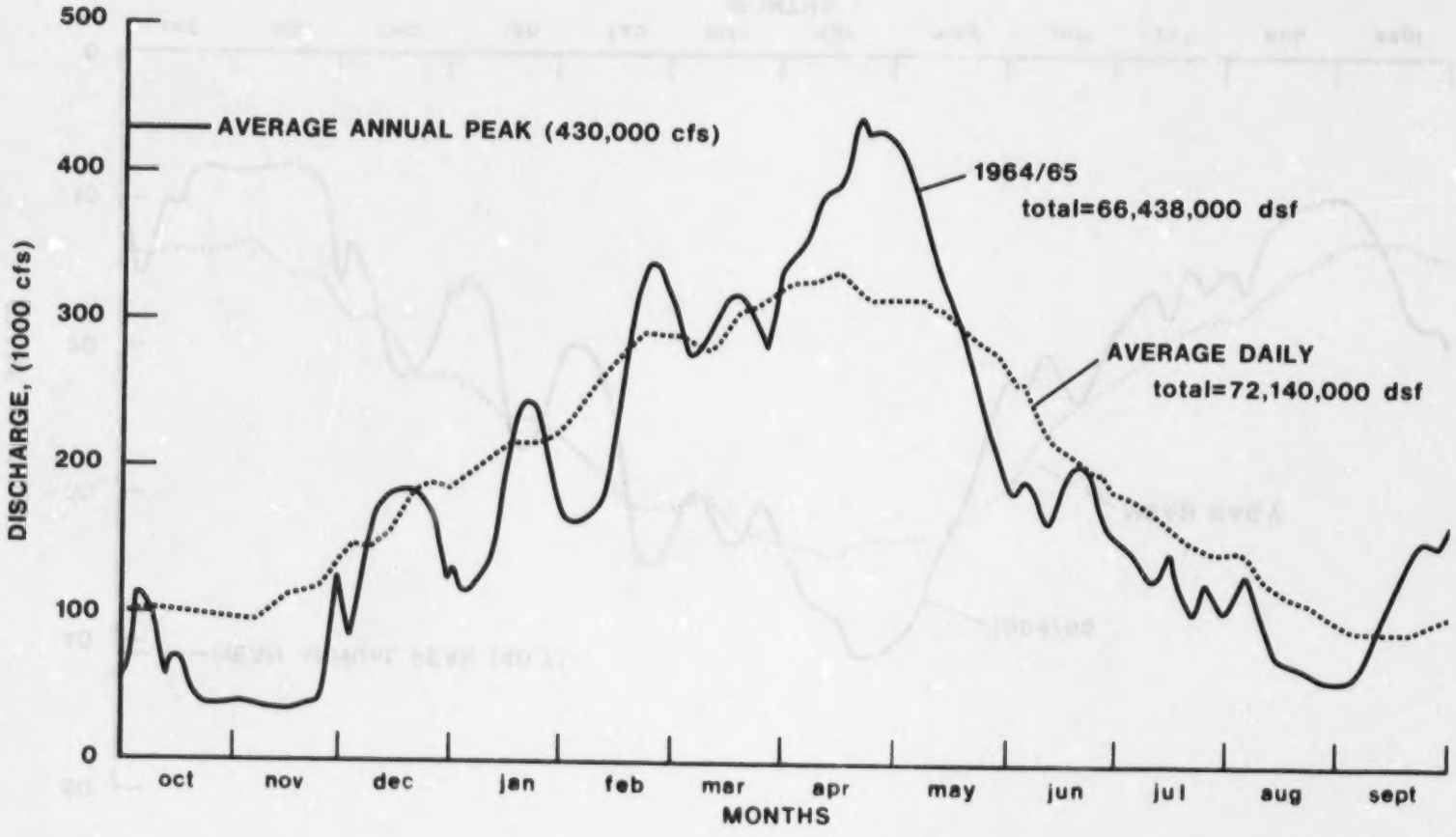


Figure 17. Annual regime of the Atchafalaya River as illustrated by average daily discharge (1949-74) and daily discharges during an average water year (1964/1965) at Simmesport, Louisiana.

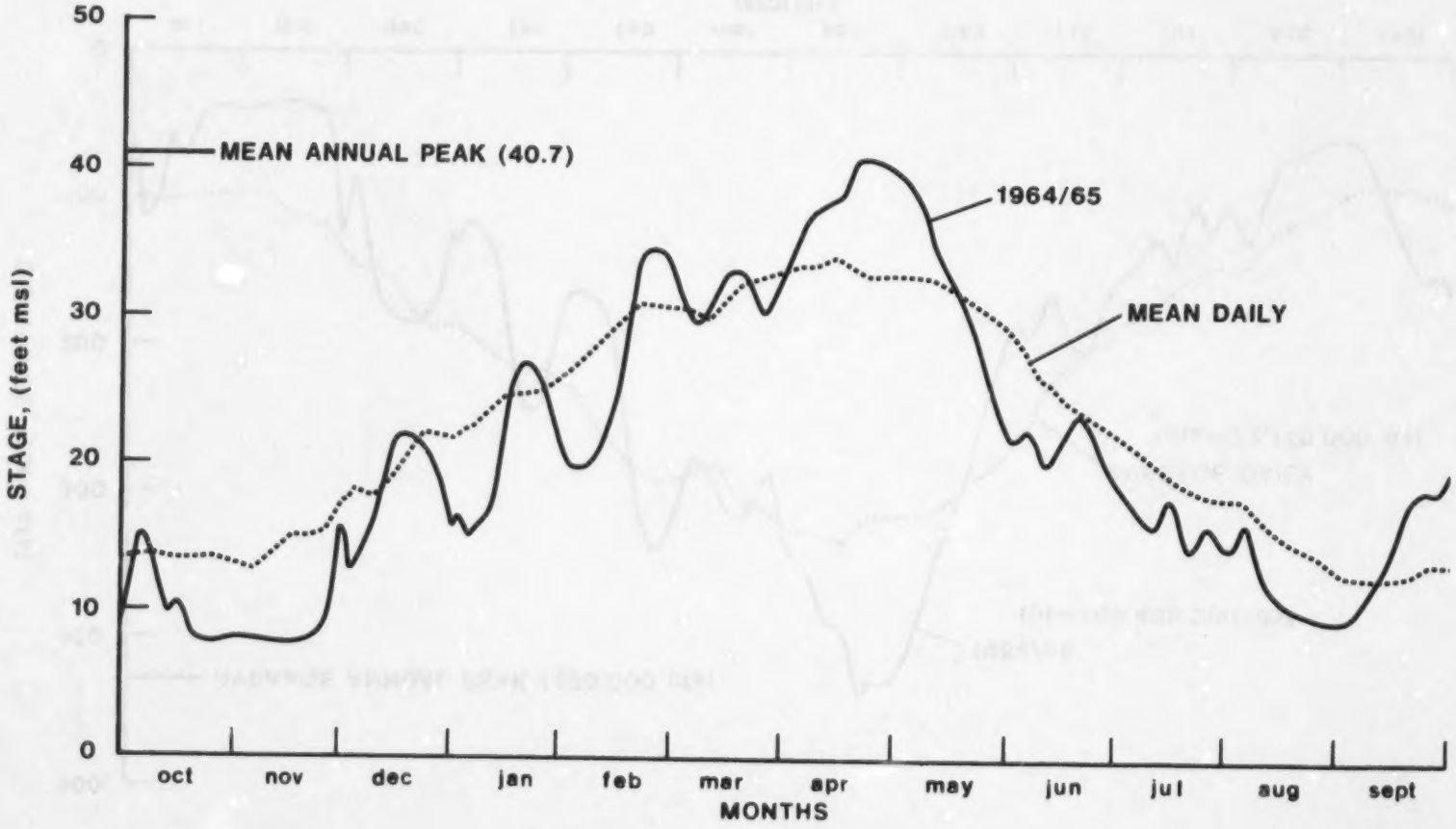


Figure 18. Annual regime of the Atchafalaya River as illustrated by average daily stages (1949-74) and daily stages during an average water year (1964/1965) at Simmesport, Louisiana.

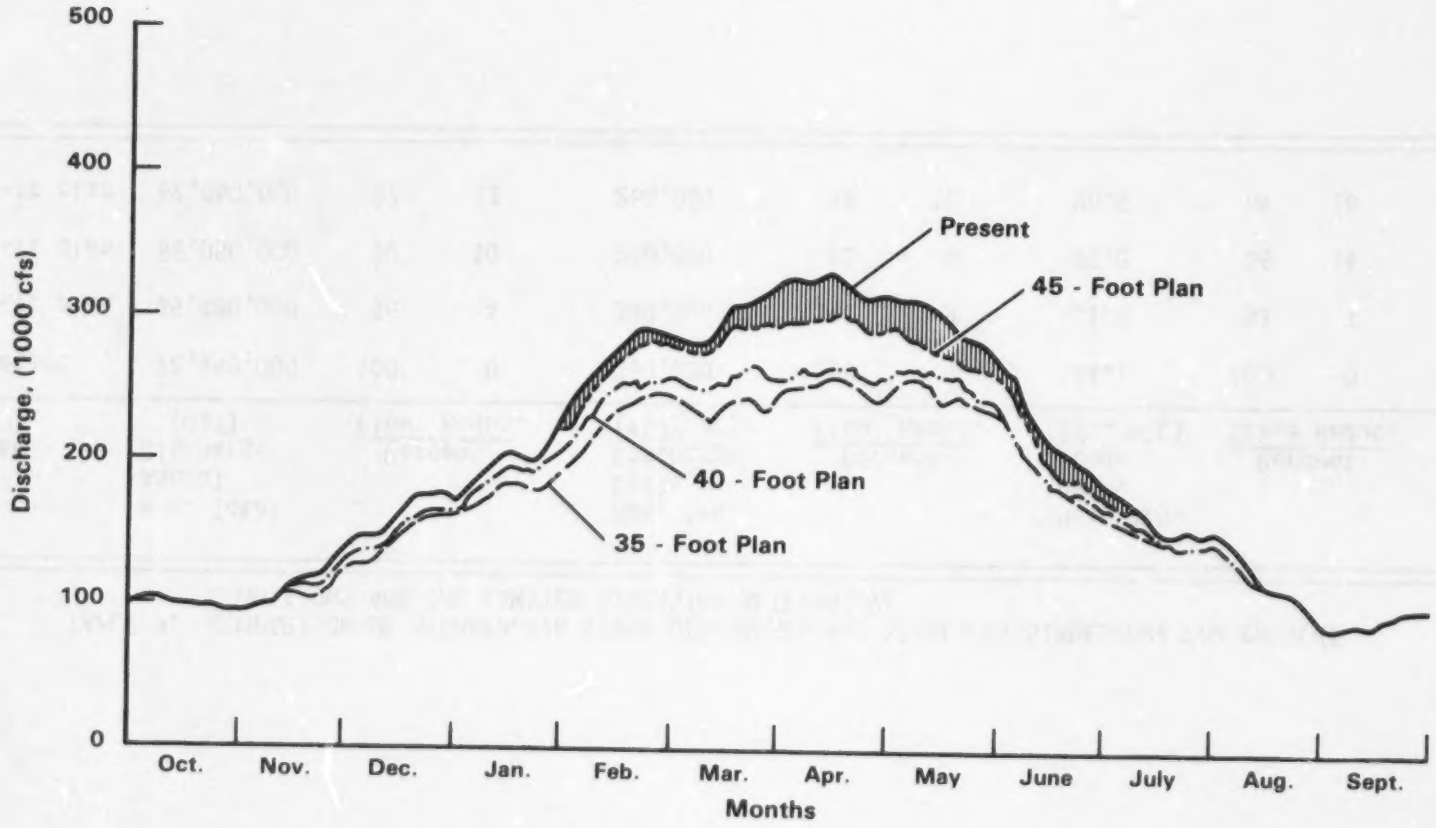


Figure 19. Average daily discharges at Simmesport, Louisiana, at present and for 35 feet, 40 feet, and 45 feet MSL.

TABLE 9. COMPARISON OF ATCHAFALAYA RIVER DISCHARGES AND STAGES AT SIMMESPORT FOR PRESENT CONDITIONS AND THE LIMITED DIVERSION ALTERNATIVE

Plan	Avg. Total Annual Discharge (dsf)	Percent Flow	Percent Reduc.	Max. Avg. Daily Discharge (ft^3/sec)	Percent Flow	Percent Reduc.	Max. Avg. Daily Stage (ft. MSL)	Percent Stage	Percent Reduc.
Present	72,140,000	100	0	330,000	100	0	34.1	100	0
45-ft plan	69,480,000	96	4	300,000	91	9	31.7	93	7
40-ft plan	65,050,000	90	10	270,000	82	8	29.3	86	14
35-ft plan	62,660,000	87	13	260,000	79	11	28.5	84	16

It should again be kept in mind that the months during which diversion is to be limited will in most years include the occurrence of annual peak flow. For the 45 ft plan, limitations of discharge will occur on the average from March 15 to June 5, and for the 40-ft and 35-ft plans from February 5 to June 15. A better evaluation of the effects of limiting the stages in the Red River backwater area and the Atchafalaya Basin Floodway complex is therefore obtained by comparing the allowable discharges and stages with the average annual peak discharge and stage and the representative hydrograph such as the one for 1964-65. These comparisons are made in Figures 20 and 21, respectively, which show the resultant reductions in flow and stage at Simmesport.

The diagrams indicate that, even with the 45-ft plan, the total annual flow through the floodway during an average water year such as 1964/1965, would have been reduced by 4,161,000 day/second/ft (dsf) or 6.2 percent. For the 35-ft plan this increased to 7,011,000 dsf or 10.6 percent. The diagrams also show that for such an average year flooding conditions in the aquatic ecosystem of the floodway would not have progressed beyond those occurring in the middle of February.

The detrimental effect of such a change with regard to integrity of the ecosystem can be evaluated by referring back to the discussion concerning the overflow regime. Reducing maximum discharge at Simmesport to 260,000 ft^3/sec would effectively remove from the aquatic ecosystem those wetlands that are presently flooded for a period of 0 to 4 months (Figures 6-8 and Table 1). This amounts to 17 percent of the floodway system below U.S. Highway 90 alone, with a range of 36 percent of the Bayou des Glaises management unit to 5 percent of the Upper Belle River unit. In area, the 17 percent translates to approximately 100,000 acres. On the basis of topographic characteristics and the percentage increase in northward direction, it must be expected that an even larger percentage would be removed from the aquatic systems in the upper floodway. Consequently, large areas of mixed bottom-land hardwood would become susceptible to clearing and agricultural development.

The removal of the mixed hardwood habitats presently flooded from 1 to 4 months represents a major perturbation of the aquatic ecosystem. These swamps serve as a nursery area for juvenile fishes and as a feeding area for adult fishes. Crawfish use these short-hydroperiod swamps as feeding and growing areas. An additional effect is caused by the elimination of the influx of detritus and related nutrients from these swamps into surrounding aquatic systems during fluctuations of water levels. This also would apply to some extent to the remaining swamps because the discharge fluctuation, during periods when 30 percent of the latitude flow exceeded the allowable diversion, would be eliminated.

In addition, the effect on commercial fishing of limiting maximum stages to mid-February conditions should be considered. No further increases in stages would greatly reduce access into the cypress-tupelo swamps, which form the backbone of commercial crawfishing. The limitation and discharge to

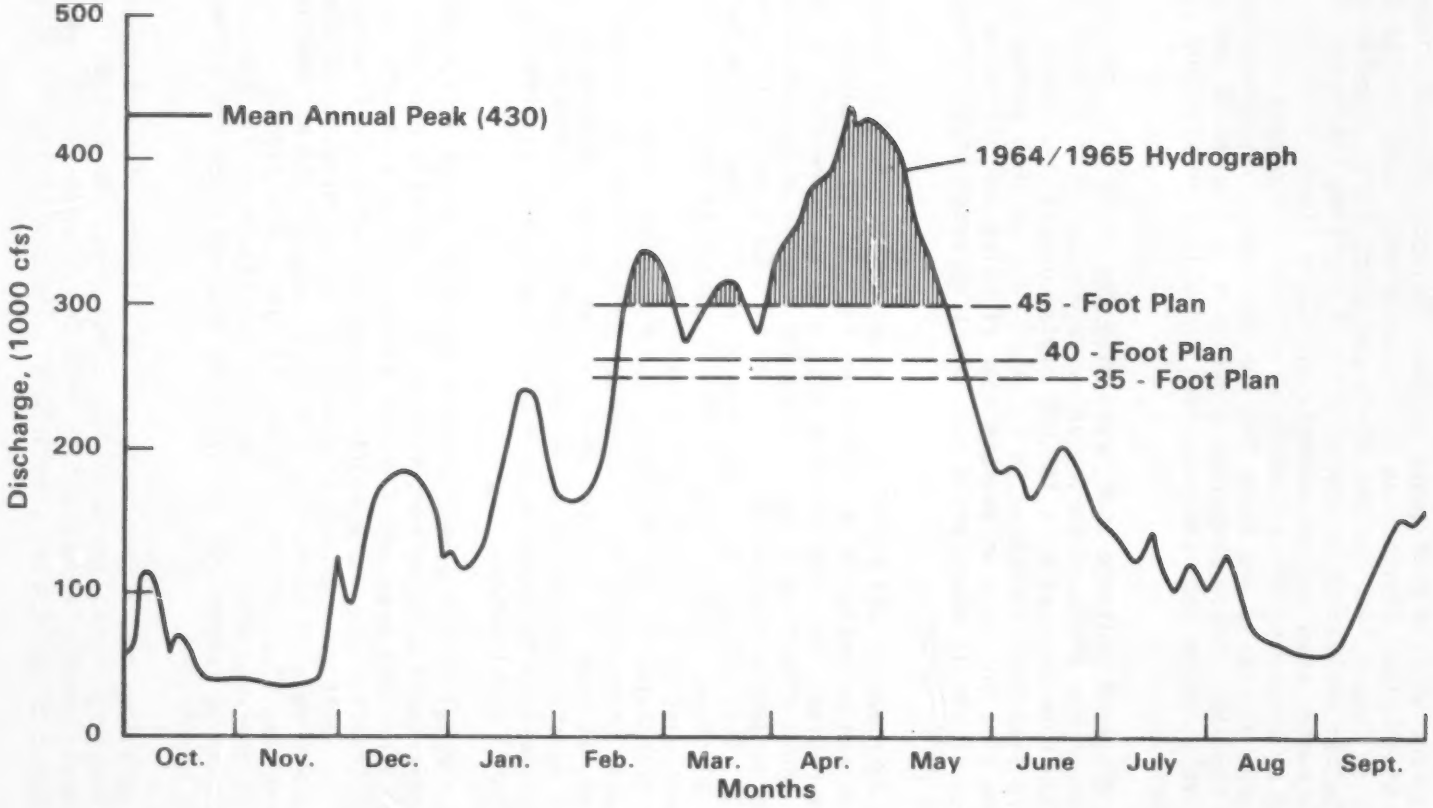


Figure 20. Comparison of Atchafalaya River discharges at Simmesport, Louisiana, for an average water year (1964/1965) with those allowable for the 35-ft, 40-ft, and 45-ft plan.

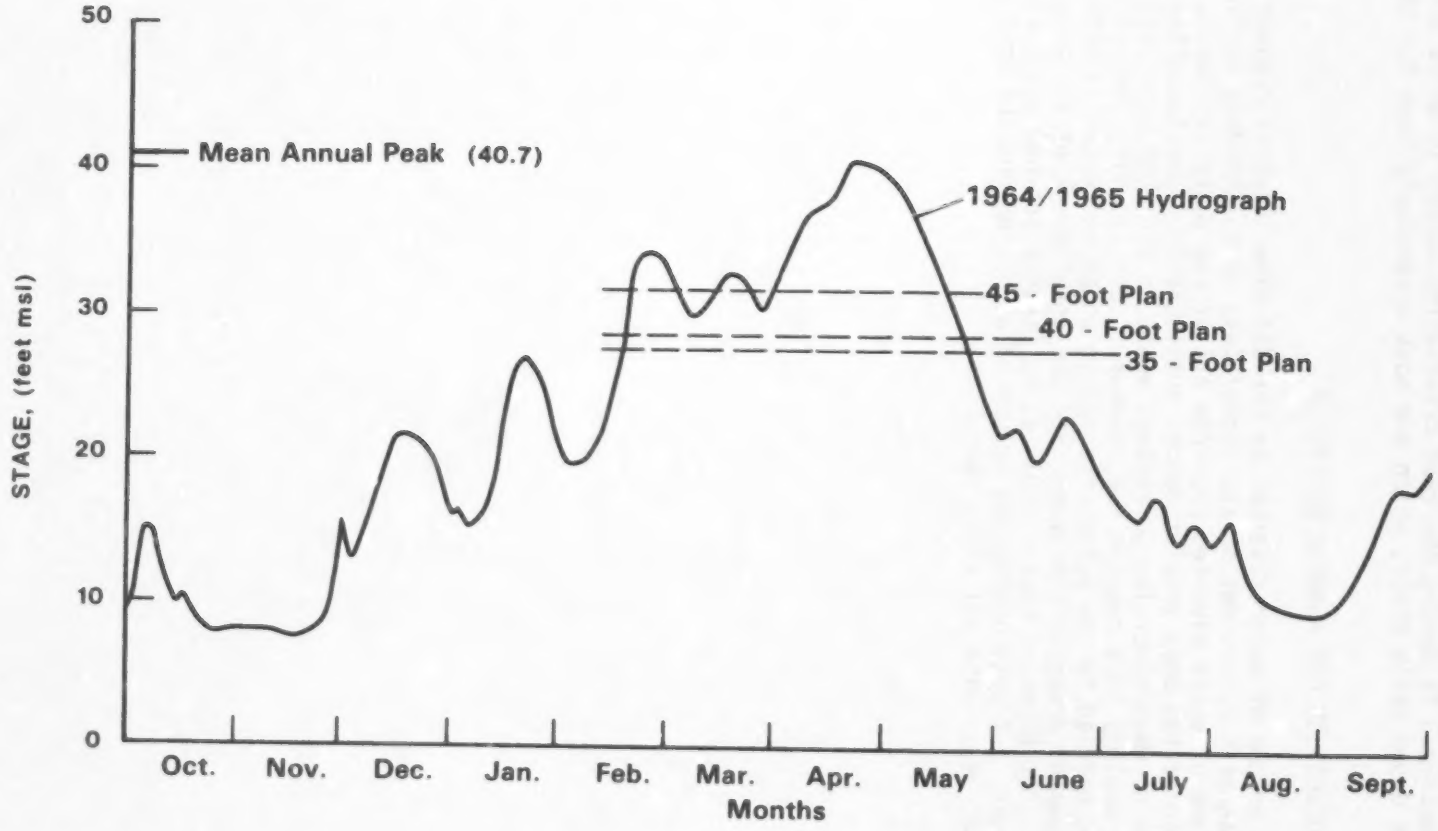


Figure 21. Comparison of Atchafalaya River stages at Simmesport, Louisiana, for an average water year (1964/1965) with those allowable under the 35-ft, 40-ft, and 45-ft plan.

300,000 ft^3/sec under the 35-ft plan would mean a reduction in stage of approximately 3 ft during the peak crawfishing season in units such as Buffalo Cove and Upper Belle River, which are most extensively used for that purpose.

MANAGE DIVERSION FOR AQUATIC ECOSYSTEM

The volume of water diverted by the Old River Control Project is critical to the aquatic ecosystems in the Atchafalaya Basin Floodway complex because the volume of water diverted provides all of the water available, with the exception of the much smaller amount available from precipitation. The question of what diversion percentage would be the most benefical to the Basin's ecology is a complex one, however. Complicating factors include the sediment carried by the water, the way in which the water is made available to the backwater areas of the swamp, and the development of the main channel system. All three of these complicating factors are now susceptible to management, but determining the volume of diversion must be done as part of a plan that deals with all these variables.

DISCUSSION

Although there is pressure to do so from the Red River backwater area, reducing the discharges would be in direct conflict with what is necessary for preserving and enhancing the natural and beneficial values of the Atchafalaya Basin's wetlands. The regime change would adversely affect the productivity of existing wetlands, their habitat diversity and stability, hydrologic utility, and associated fish and wildlife resources (and the commercial, recreational, and other uses thereof) by reducing extent, duration, and depth of annual flooding. Direct loss of wetlands would occur particularly in the Bayou des Glaises, Bayou Fordoche, Pigeon Bay, Cocodrie, Beau Bayou, and Buffalo Cove management units and would greatly alter existing habitats in all management units. The change would effectively remove from the aquatic ecosystem those wetlands that are presently flooded for a period of 0 to 4 months. This type habitat represents as much as 36 percent of the wetland system of the Atchafalaya Basin Floodway below U.S. Highway 190. Similar changes would occur in the Red River backwater area.

Without stronger land-use controls, a reduction in the annual extent of flooding would encourage new residential and agricultural development in present wetlands. This in turn will increase agricultural runoff into adjacent wetlands, which are already affected by such runoff and in which circulation is impeded by a backwater regime as a result of past flood control measures.

In order to minimize the present loss of wetlands as a result of river profile adjustments, the present diversion ratio must be at least maintained. However, the complete maintenance of present wetlands requires an increase of diverted discharge to offset the trend toward reduced extent, duration, and depth of flooding as experienced by all but three of the management units.

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APPENDIX

CONVERSION FACTORS

In this report, English units are frequently abbreviated using the notations shown below. The English units can be converted to metric units by multiplying the factors given in the following list:

English unit to convert	Multiply by	Metric unit to obtain
acres	4,047	square meters
cubic feet per second (ft^3sec)	0.02832	cubic meters per second
cubic yards (yd^3)	0.7646	cubic meters
day/second/feet (dsf)	0.02832	day/second/meters
feet (ft)	0.3048	meters
miles (mi)	1.6093	kilometers
square feet (ft^2)	0.09290	square meters
square miles (mi^2)	2.590002	square kilometers